POWER

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Power Wants Antennæ

POWER wants a friend in every corner of the country, in every organization of engineers, in every large company where things transpire or news is made that is interesting to power-plant engineers.

If we had enough of these antennae out so that we got quick knowledge of everything that happened of interest in the field, we could make *Power* better for you and for everybody.

We want not only to publish the things that power-plant people want to know in the way that they like best to read them, but we want to publish them promptly and not skip any of them.

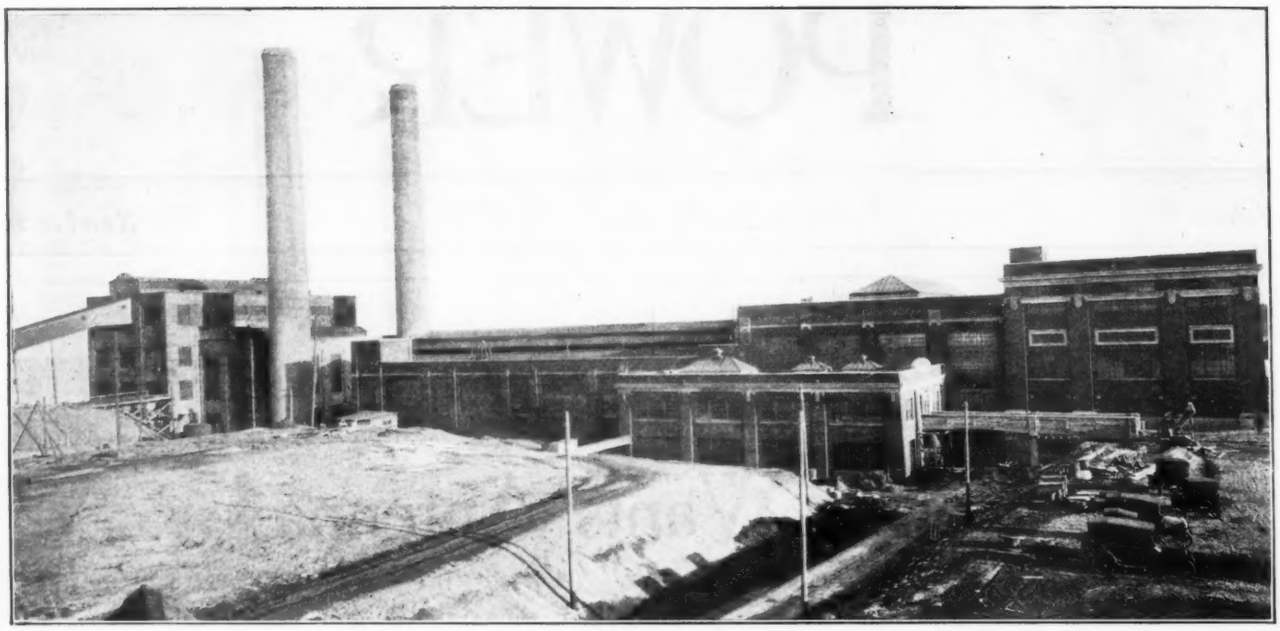
We have a large force in the field, we have a large staff of editors, conducting a voluminous correspondence, but things that many of our readers would like to see in *Power* get by or are slow in coming in.

We should like to have prompt information when a new and interesting plant is to be installed or an old one extended; when an important invention is brought out, an improvement in practice developed, a valuable test or research made; when a meeting of more than local interest is held and worth-while papers are presented; when accidents occur of which sufficient particulars are obtainable to be of real engineering interest and value, such as boiler, economizer, pressure-vessel and pipe explosions, flywheel wrecks and engine and turbine failures. We should like to know when men of prominence change positions, are elected to office, accomplish something particular or pass away. We need early advice concerning engineering legislation, boiler laws, smoke ordinances, engineers' license laws, oil-storage regulations, etc.; decisions by courts, public-service commissions, etc., upon questions affecting power-plant interests.

We want somebody everywhere who will feel that he is one of the *Power* family, who will think of *Power* and of the engineers that it represents and serves every time that anything happens that they would like to know about.

We do not expect our friends to do this for nothing. We would be glad to make it worth their while. Would you be interested to try? If so, send in a note about the next thing that happens that you think we can use, and I am sure that we can come to an understanding through which we can be useful not only to each other, but to the profession.

F. R. Low



Largest Station Using Pulverized Coal

Lakeside Station at Milwaukee, the First Large Central Station To Use Pulverized Coal Exclusively—Laid Out for 200,000 Kw., of Which 40,000 Kw. Is Installed

IN 1915 the Milwaukee Electric Railway & Light Co. found it necessary to make a study of its increasing power demands, which resulted in general plans for a 200,000-kw. plant, the first section to be built for 40,000 kw. Accordingly, in 1916 land was purchased, including 6,000 ft. of frontage on Lake Michigan and a railroad right-of-way connecting to the Chicago & Northwestern R.R. Up to that time coal for power purposes was being received entirely by lake transportation, so that coal docks and a protecting harbor were considered essential features of the plant. These docks were designed with rail connections so that any coal received by rail could be handled and stored as easily as that received by boats.

Owing to the conditions occasioned by the world war, in 1917 it was found impossible to go ahead with the project. But at the end of 1919 the increased load made it imperative to begin again. Accordingly, on Dec. 22, 1919, orders were issued to proceed with the plans and rush through the construction of the first section of the new plant, including two 20,000-kw. turbine units, so as to have this capacity in readiness, if possible, to deliver power on Nov. 1, 1920.

In the meantime, since the plant was first planned, important changes had occurred in the practice of the company with regard to securing coal. The regional orders of the Fuel Administration had compelled the use of low-grade Illinois fuel, in place of the Eastern coal formerly used and considered in the original plans for the plant. The changed conditions necessitated a design for the exclusive use of rail coal, which required an entirely different layout of buildings and grounds from that originally contemplated, leaving the harbor and docks as a remote future possibility. This change in plans was also largely influenced by the results of experiments in the use of pulverized coal which the company had been conducting at its Oneida Street power plant.[1] In the course of these experiments the utilization of this fuel had been perfected to such an extent that it was decided to equip the new plant for the use of pulverized fuel exclusively.

The site averages about 50 ft. above lake level, with a steep bluff at the shore. It was desired to provide a suction chamber at the lake level and to place the condensers at such a level that the water could be circulated through them with a minimum lift, as otherwise an enormous amount of energy would be expended in raising the condensing water. This necessitated placing the condensers at a low level which, in turn, determined the level for the turbines and boilers.

The present installation includes the rail connections, coal-storage yards, coal-handling and crushing plants, a breakwater for impounding cooling water and the cooling-water intake and discharge tunnels, each of a capacity sufficient for a total output of 200,000 kw. Present needs are met by the 40,000-kw. section of the station now completed.

In the main building are the boiler room, turbine room and switchhouse arranged in the order named. The coal-pulverizing plant is in a separate building about 50 ft. back of the boiler room. Between these two buildings are two concrete chimneys, each of which serves four boilers. On one side of the main building opposite the turbine room is a connecting building in which will be located the operating engineers' offices, a blacksmith shop, a pipe shop and a machine shop. The remaining building is the car-dumping and crusher plant, which is on the shore of the lake about 400 ft. distant from the pulverizing plant. This building is

[1] See *Power*, March 2, 1920.

FIG. 1. BOILER AISLE, SHOWING PULVERIZED COAL FURNACES ON LOWER LEVEL

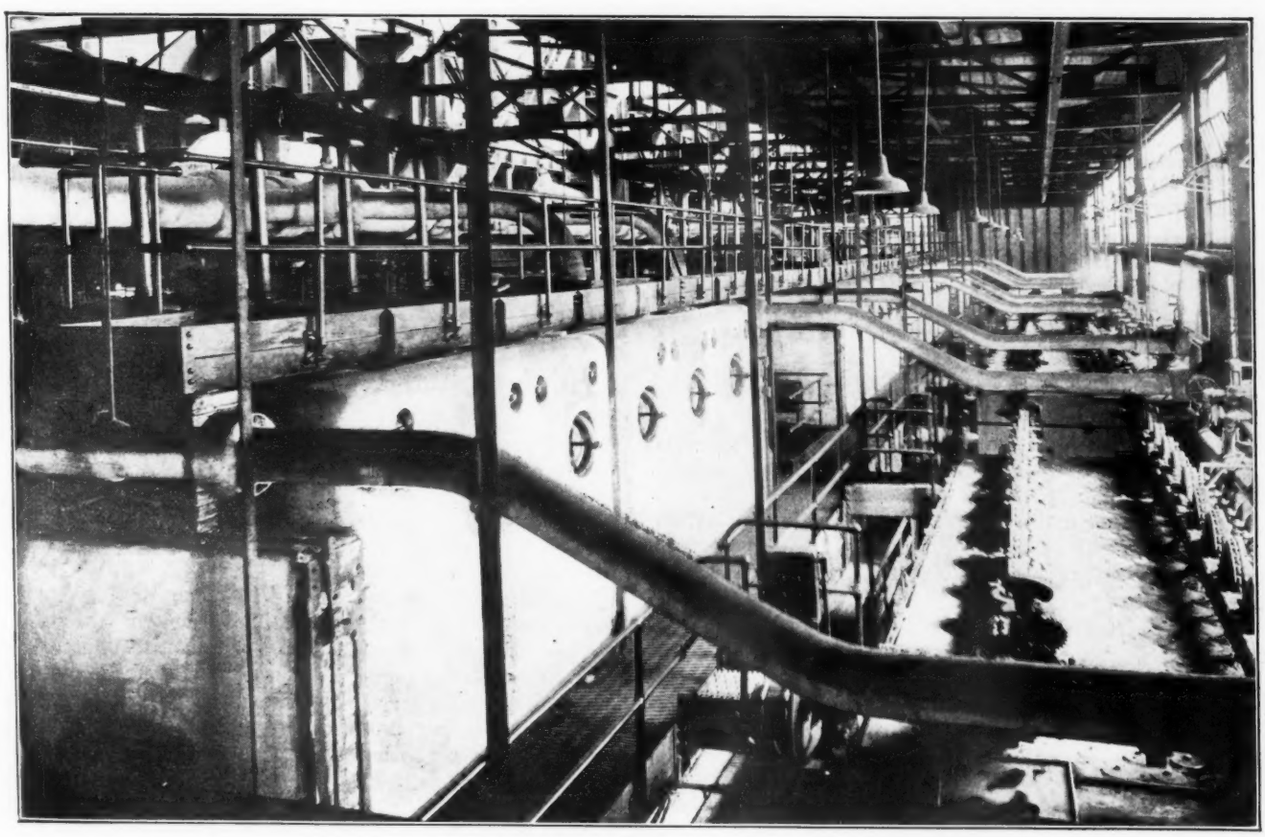


FIG. 2. REAR OF BOILERS, SHOWING TOPS OF ECONOMIZERS

placed against the side of the bluff to take advantage of the slope to secure a gravity flow for the coal.

The coal dumping and crushing plant presented peculiar construction difficulties, being located on the slope of the bluff at the lake shore. The coal cars are brought in to the dumper on the high level at an elevation 56 ft. above the lake. The crushing building is surrounded on three sides by high retaining walls, the west wall of the building forming a retaining wall nearly 50 ft. high and the two end walls being braced to the building floors by means of concrete struts, thereby reducing the spans for the concrete, and the materials required for the walls.

There are eight 13,060-sq.ft. water-tube boilers, deranged from 137 to 236 per cent of rating, the fuel burned per cubic foot of combustion space, varied from 0.85 to 1.62 lb.

Each boiler is served by an individual economizer of 7,603 sq.ft. arranged with a bypass connection to the stack, and each economizer is equipped with a turbine-driven induced-draft fan. Feed water enters at a temperature approximating 140 deg. F. and is raised to 255 deg. F.

The Feed Water System

From the condensers the condensate is pumped to an overhead hotwell tank, the water from which feeds by gravity to two open heaters maintaining a fairly con-

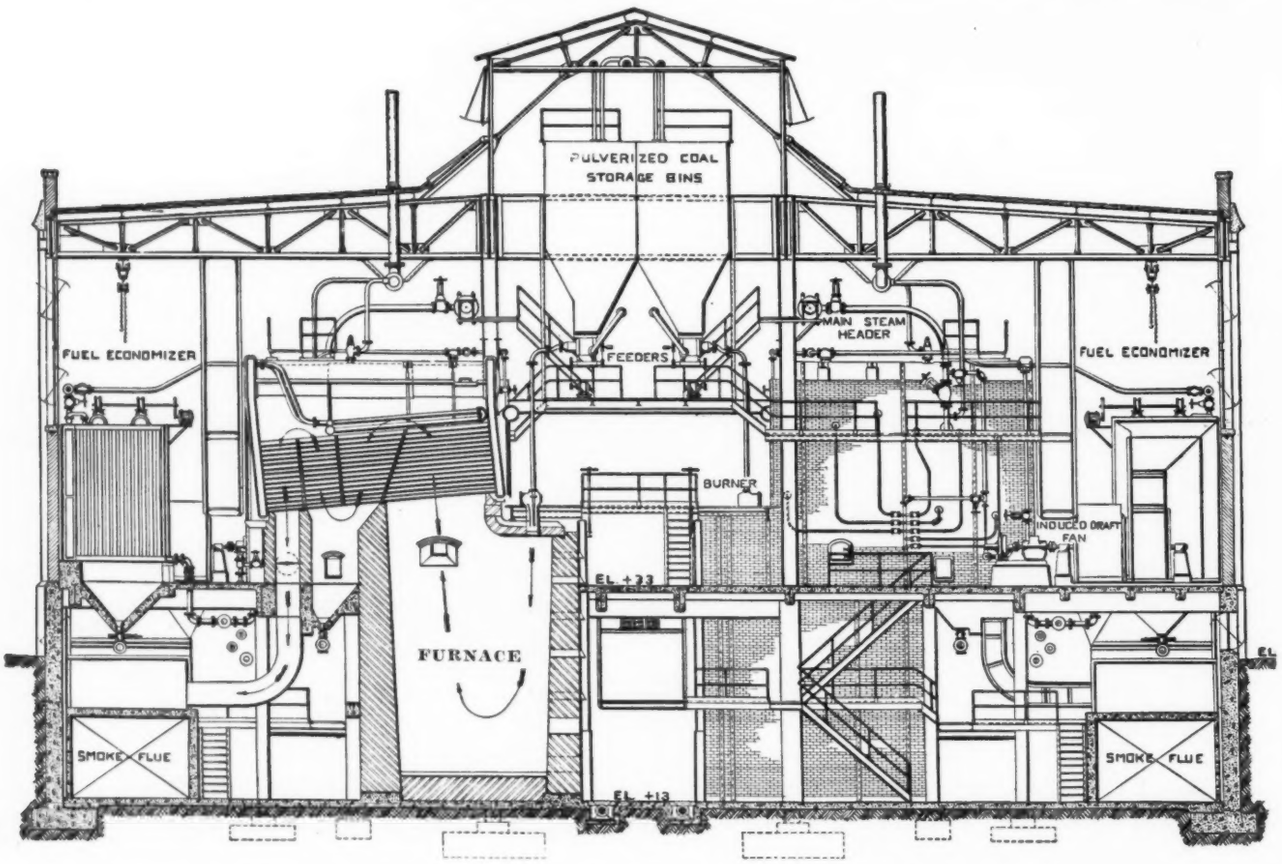


FIG. 3. TRANSVERSE SECTION THROUGH BOILER HOUSE

signed for 300 lb. pressure but operated at 265 lb. gage. These are arranged four on each side of a central firing aisle. They operate normally at 250 per cent of rating, and three boilers are sufficient to furnish steam for one 20,000-kw. turbine, leaving two spare boilers to allow for cleaning and maintenance. Each boiler has a superheater capable of raising the temperature of 90,100 lb. of steam per hour from 411 to 611 deg. F., thus realizing a superheat of 200 deg. F.

Pulverized fuel is fed to the furnaces by screw feeders from overhead storage bins. Six out of the eight furnaces were fed from the top with the coal discharging vertically downward, while for experimental purposes, the other two were fitted with horizontal burners. Recently, however, the horizontal burners have been replaced and in all furnaces the vertical method of feeding fuel is employed. The furnace volume is approximately 7,000 cu.ft. In certain tests in which capacities

stant pressure on the supply pipe thereto. The heaters raise the temperature of the feed water from approximately 80 deg. to 140 deg. F. The overhead hotwell tank has an overflow to a reserve feed-water basin located below the basement floor of the boiler room. Water is reclaimed from this basin by means of centrifugal pumps and is delivered to the overhead hotwell tank as needed. From the heaters the feed water passes by gravity through an 800,000-lb. per hour V-notch feed-water meter located on the floor above the feed pumps. There is also installed a common test line, with connections from condensate pumps on each condenser, which discharges into a test meter of the V-notch type of 300,000 lb. per hour capacity, from which it flows by gravity into the heaters. The test meter is on the same floor level with the overhead hotwell tank.

There are two 6-in. centrifugal 650-gal. per min. feed pumps driven by 250-hp. steam turbines and two 4-in.

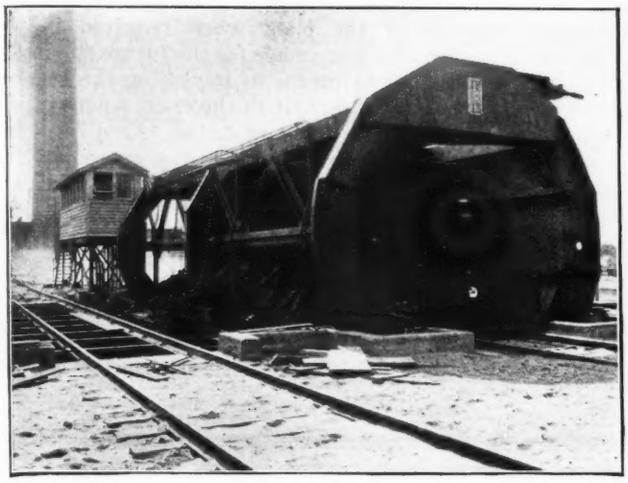


FIG. 8. ROTARY CAR DUMP IN DUMPING POSITION

This dumper can handle twenty cars per hour, the coal falling by gravity to the crusher.

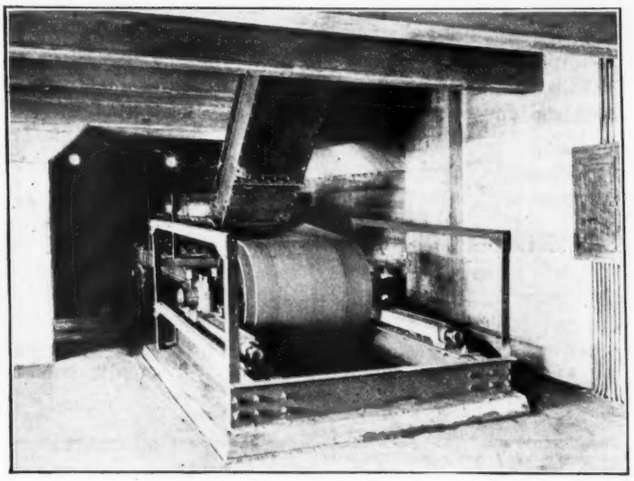


FIG. 11. FROM HAMMER MILL TO BELT CONVEYOR

The ½-in. coal is fed from the hammer mill to an inclined belt conveyor leading to the pulverizer.

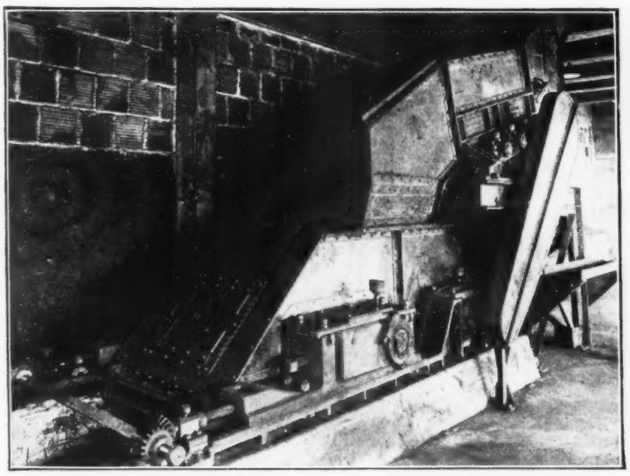


FIG. 9. TWO-ROLL CRUSHER AND GRIZZLY

The grizzly screens out coal 2 in. and over and discharges to the crusher where it is reduced to under 2 in.

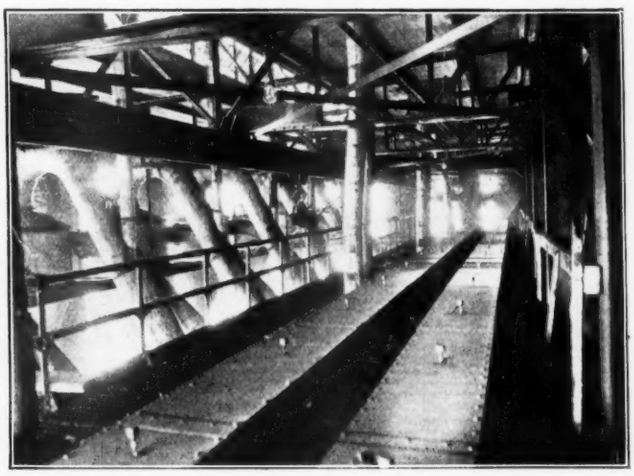


FIG. 12. DUST COLLECTORS AND SCREW CONVEYORS

Gas from the dryers is forced through the dust collectors. Powdered coal is carried to the mill bin by parallel screw conveyors.

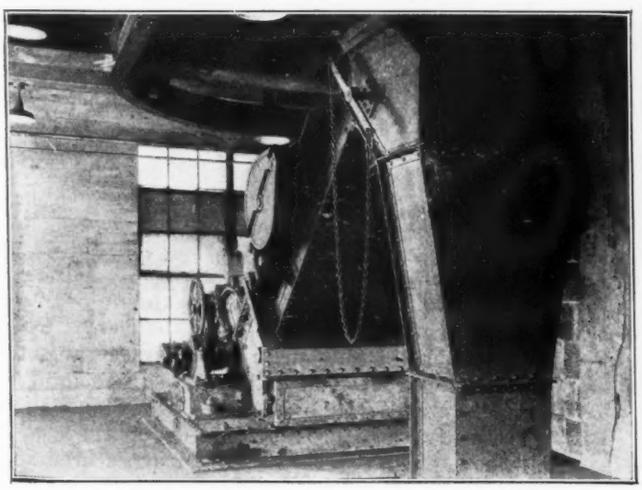


FIG. 10. HAMMER MILL AND BYPASS CHUTE

Crushed coal and that from the grizzly is fed through the hammer mill and reduced to ½ in. size; finer coal is bypassed.

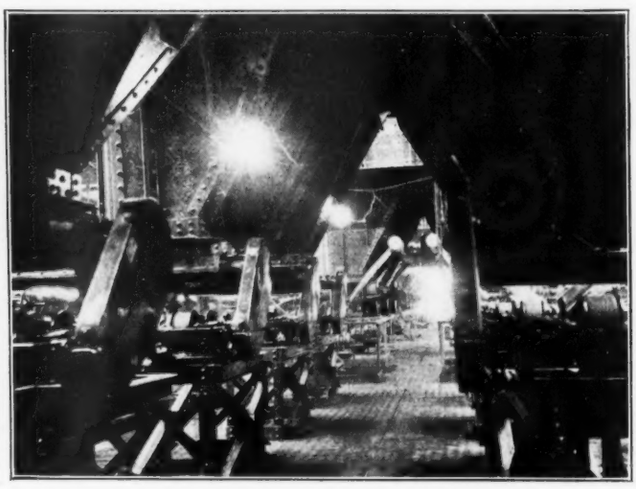


FIG. 13. COAL BINS OVER BOILER AISLE

Each set of bins will hold 150 tons. These feed the pulverized coal through vertical pipes to the burners.

Views Showing Progress of Coal Through Preparation Plant

centrifugal 400-gal. per min. feed pumps driven by 150-hp. motors, all operating against a pressure of 325 lb. gage. The maximum quantity of feed water required for eight boilers operating at 250 per cent of rating is 1,450 gal. per min. This leaves two motor-driven pumps, or one steam-driven pump as spares.

Coal-Handling System

Coal trains with the daily supply of fuel are passed through a revolving car dumper, one car at a time, at a maximum rate of about twenty cars an hour. This dumper is located on a bluff running along the lake, and coal passes by gravity through the crushing-plant machinery in the following order: Through bottom shaker feeders coal is fed from the hoppers under the dumper to a 48-in. belt conveyor delivering to a rotary grizzly. The head pulley of the conveyor is highly magnetized and carries tramp iron to its under side, thus separating it from the coal. The grizzly screens out coal 2-in. and over and discharges it into a two-roll crusher, which reduces it to 2-in. and under. The crushed coal, together with that passed through the grizzly, is fed through a hammer mill, which reduces it to ½-in. in size, and onto a 36-in. belt conveyor which leads to the pulverizing plant.

When operating as described, the crusher plant will handle 150 tons per hour. When fine coal is received, it is bypassed directly to the belt conveyor under the hammer mill, and 250 tons an hour at 250 ft. a minute can be handled. The crusher building is designed to accommodate two grizzlies, crushers and hammer mills, and when the extra set is installed it will double the present capacity of the plant when required in the future. Provision has been made for the future storing of rail coal on the dock by means of bypassing the crusher and conveying the coal by belt to the dock, where it will be taken up by a coal bridge and stored. Coal from the dock will be reclaimed by reversing the operation and delivering coal reclaimed into crushers. Lake coal will be taken into the plant in the same way.

Coal-Preparation Plant

The belt conveyor leading to the pulverizing building is 36 in. wide and, in its length of 385 ft., rises 91 ft. It discharges onto a reversible cross-belt conveyor of the same width, which distributes the crushed coal to three parallel conveyors equipped with automatic trippers which pass over the green-coal storage bins in the pulverizing building and maintain an even supply in them. There are seven of these bins, having a combined capacity of 3,400 tons, which is slightly more than three and one-half days' supply for maximum operation of all boilers in the present section of the plant. Under the bins run three 12-in. screw conveyors arranged to discharge through automatic scales into three indirect-fired rotary dryers 5 ft. 6 in. in diameter and 40 ft. long. These dryers reduce the moisture in the coal by means of hot gases from individual furnaces fired with pulverized coal.

With the foregoing arrangement it is possible to take coal from any point in the bunker and deliver it to any one of the three dryers. It also allows the coal to be weighed just before reaching the dryers, which is much to be preferred over the method of measuring coal as it

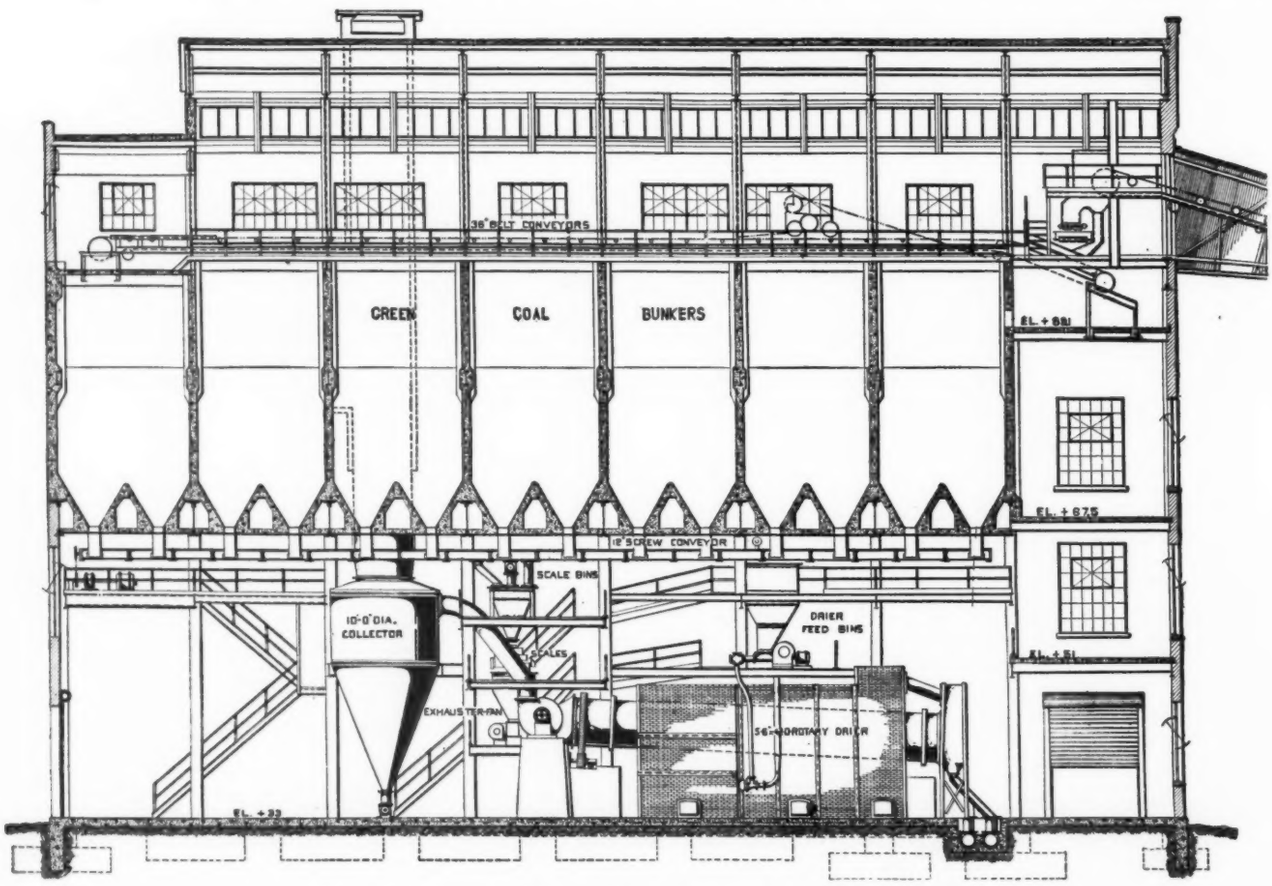


FIG. 10. LONGITUDINAL SECTION OF PULVERIZING PLANT

enters the coal bunker, inasmuch as it permits of a close daily check on coal consumed in the plant. Each dryer is capable of reducing the moisture content in 10 tons of coal an hour from 10 to 2 per cent.

After being exhausted from the dryer, the gas is blown through collectors 14 ft. in diameter, which recover any coal dust it carries away in passing through the agitated coal. The hot, dried coal is next transported to the mill feed bins by means of parallel arrangements of 16-in. screw conveyors and continuous bucket elevators, each set having a capacity of 60 tons an hour. The idea is to provide spare capacity in case of breakdown.

There are eight mill-feed bins, each holding 25 tons and placed over its respective mill. Ball pulverizing mills utilizing the air-separation system and driven by 100-hp. motors, have a total hourly capacity of 48 tons. The mills pulverize to a fineness so that 75 per cent will pass through a 200-mesh screen and 90 per cent through a 100-mesh screen. With the air-separation method no screens are needed; an exhauster driven by the mill shaft draws a current of air over the bull ring in the mill, and the velocity of this air is such that it picks up only those particles that have been ground to the necessary fineness. The dust thus formed is forced through a collector, which separates the coal, and the air is conducted back to the mill to be drawn through again, thus making a continuous circuit. From the collectors the pulverized coal is conveyed to a 50-ton storage bin supplying a pneumatic conveying system which transports it to four sets of bins over the firing aisle in the boiler room. One set of bins will hold 150 tons. Coal is fed to each boiler through three duplex vertical

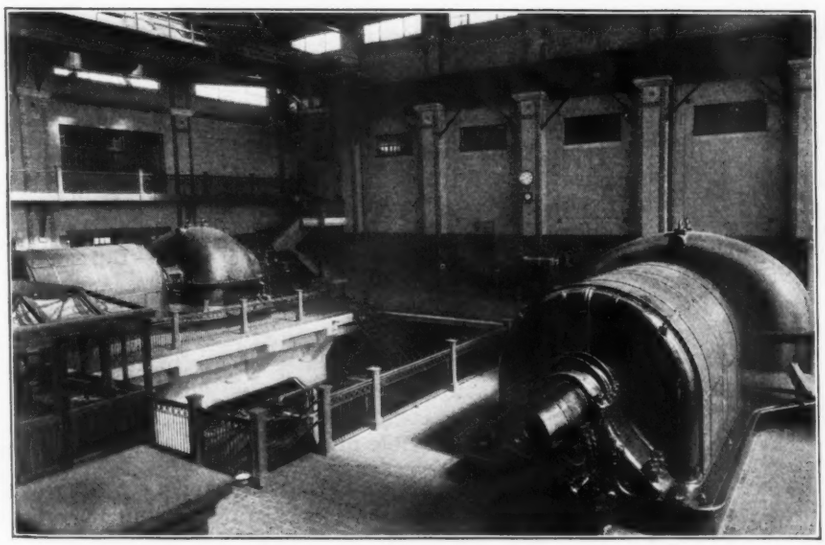


FIG. 14. THE TURBINE ROOM NOW CONTAINS TWO 20,000-KW. UNITS

burners or four horizontal burners, as previously described.

As the quantity of ash from pulverized-fuel furnaces is small and fine, it is easily conveyed by means of steam-jet ash conveyors. A system of steam-jet conveyors is installed with main runs leading to furnace ashpits and branches leading to combustion chambers at the rear of the boilers and soot pits under the economizers. Ashes are removed by hand through clean-out doors in the boiler-room basement and fed into the conveyor pipe line. The conveyor discharges into an ash bunker which spouts into cars on the railroad track at the east end of the boiler room.

Maintaining Heat Balance

It was decided, in order to obtain a well-balanced heat condition, to install steam-driven boiler-feed pumps, induced-draft fans and half of the circulating-pump

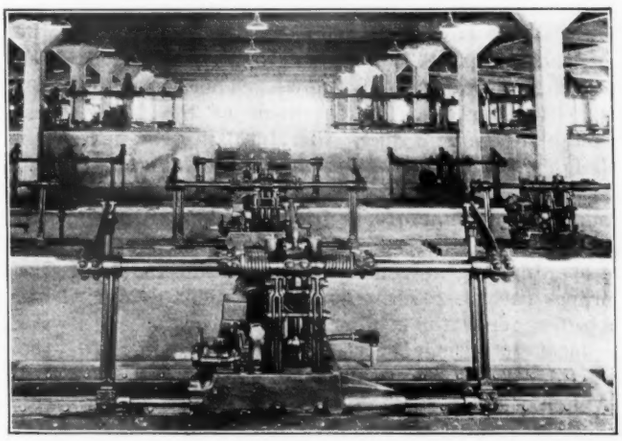


FIG. 15. FEEDER GROUP OIL SWITCHES WITH STRUCTURE AND MECHANISM AT THE FLOOR LEVEL

capacity, leaving the remainder of steam required for heating feed water to be supplied in varying quantities by the house unit, or so-called heat balancer. All other auxiliaries are motor-driven.

The heat balancer is a 500-kw. turbo-generator which supplies current at 480 volts for station use. The turbine end of this machine is equipped with a diaphragm-operated governor controlled by a thermostatic device located in the feed-water heaters. The purpose of such an arrangement is to regulate the temperature of the feed water by varying the amount of the exhaust steam passing into the heaters from this turbine. The electrical load on the generator side is balanced through a transformer connected to the main station buses. With the aid of this unit the main turbo-generators can be started under a vacuum in cases of complete isolation from an outside source of power, as the electrical auxiliaries of the condenser can be operated with current supplied from it.

In the turbine room the main generating units consist of two 20,000-kw. turbo-generators, 13,200-volt three-phase 60-cycle machines, the steam ends operating at 250 lb. pressure, 200 deg. F. superheat and 1 in. abs. back pressure at a speed of 1,800 r.p.m.

Excitation for the generators is furnished at 240 volts and is normally supplied for each generator by its own direct-connected exciter. Emergency excitation is furnished from the direct-current station power service. The oil-switch control system is 120 volts direct current, regularly supplied from a separate storage battery and

special motor-generator sets. If necessary, the oil-switch control may be transferred immediately to the battery on the direct-current station power system by connecting it across one-half of the cells.

An air washer is installed for each generator, which draws its supply from the main turbine room, thereby eliminating a separate screenhouse and air duct to the outside of the building. Suitable means of admitting air into the turbine room from the outside during the cold weather have been made in the monitors on the roof, while during the milder weather it is admitted through ventilators in windows. The generators discharge the air into the basement of the boiler room through sheet-metal ducts, thereby using the heated air to augment the regular supply to the boiler furnaces. Provision was made in these discharge ducts to bypass a sufficient amount of air back into the turbine room during cold weather so as to temper the air and reduce the openings of the ventilators to a point that will give a proper turbine-room temperature. This design of air ducts for generator cooling gives the best results with the least investment cost, and also provides for the reduction of noise as much as possible.

Automatic dampers have been installed in both the air intake and discharge ducts as close to the generator as possible as a means of fire protection. These close when an unusually high temperature is obtained such as might be occasioned by fire, and arrangements have been made for admitting high-pressure steam for fire extinguishing.

Condensing Equipment

Auxiliaries for each generating unit comprise one 35,000-sq.ft. three-pass surface condenser; two 24-in. 18,000-gal. per min. circulating-water pumps, one driven by a 170-hp. motor and the other by a steam turbine of the same rating; one condensate pump driven by a 50-hp. motor; one turbo-air pump driven by a 100-hp. motor, and as a reserve a steam-jet air pump. Each condenser is thus provided with two half-capacity circulating-water pumps. Both of these pumps will be required during the summer months when the water is warm, but only one will operate during the winter.

SUMMARY OF BOILER TESTS WITH PULVERIZED COAL AT LAKESIDE POWER PLANT, BOILER NO. 8

Test No.	Duration Hours	Rating per Cent	Eff. of Boiler and Superheater	Eff. of Boiler Superheater and Economizer	CO_2 in Gases Leaving Boiler	Temp. of Gases Leaving Boiler	Temp. of Gases Leaving Economizer	Kind of Coal
1	42.3	137	83.3	86.3	15.8	434	168	Dried
2	24.0	215	82.6	87.1	14.6	475	196	Illinois
3	20.0	209	82.5	87.0	14.7	482	205	Coal
4	24.7	146	85.4	89.1	16.0	430	204	"
5	24.2	236	79.8	84.6	14.1	496	251	"
6	28.2	139	83.8	88.0	15.1	454	229	Undried
7	25.6	177	83.7	88.0	14.7	466	242	Pennsylvania
8	24.0	175	85.2	89.6	15.1	463	239	& Ohio
9	24.3	204	83.9	88.3	15.1	487	256	Coal
10	24.6	203	83.0	87.0	14.7	474	256	"
11	24.1	244	80.2	85.0	14.0	530	286	"
12	23.9	241	81.7	86.4	14.2	524	263	"
13	24.2	251	81.0	85.6	14.2	531	272	"
14	24.5	130	84.7	88.5	17.1	435	218	"
15	17.6	137	84.4	88.4	16.4	440	221	"

The ultimate 200,000-kw. plant will require water for condensing purposes at the rate of 360,000 gal. per min., or 518,000,000 gal. per 24 hours. To secure this supply from the lake without going into deep water, it was decided to build a rubble mound inclosure extending approximately 485 ft. out from the shore and 850 ft. long to provide in effect, a pond of still and clean water. The discharge tunnel is arranged so as to discharge either inside or outside of this basin, so that in the winter time the warm discharge water can be used to prevent the basin from freezing.

This rubble mound is designed with a height of 8 ft. from the normal surface of the water, with a width of 10 ft. on the top and a slope of 2 to 1 on the lakeside and 1½ to 1 on the inner face. As the outer wall is in 16 ft. of water, the base at the maximum point is 91 ft. wide. The core of this mound consists of quarry-run limestone having a minimum size of 3 in.

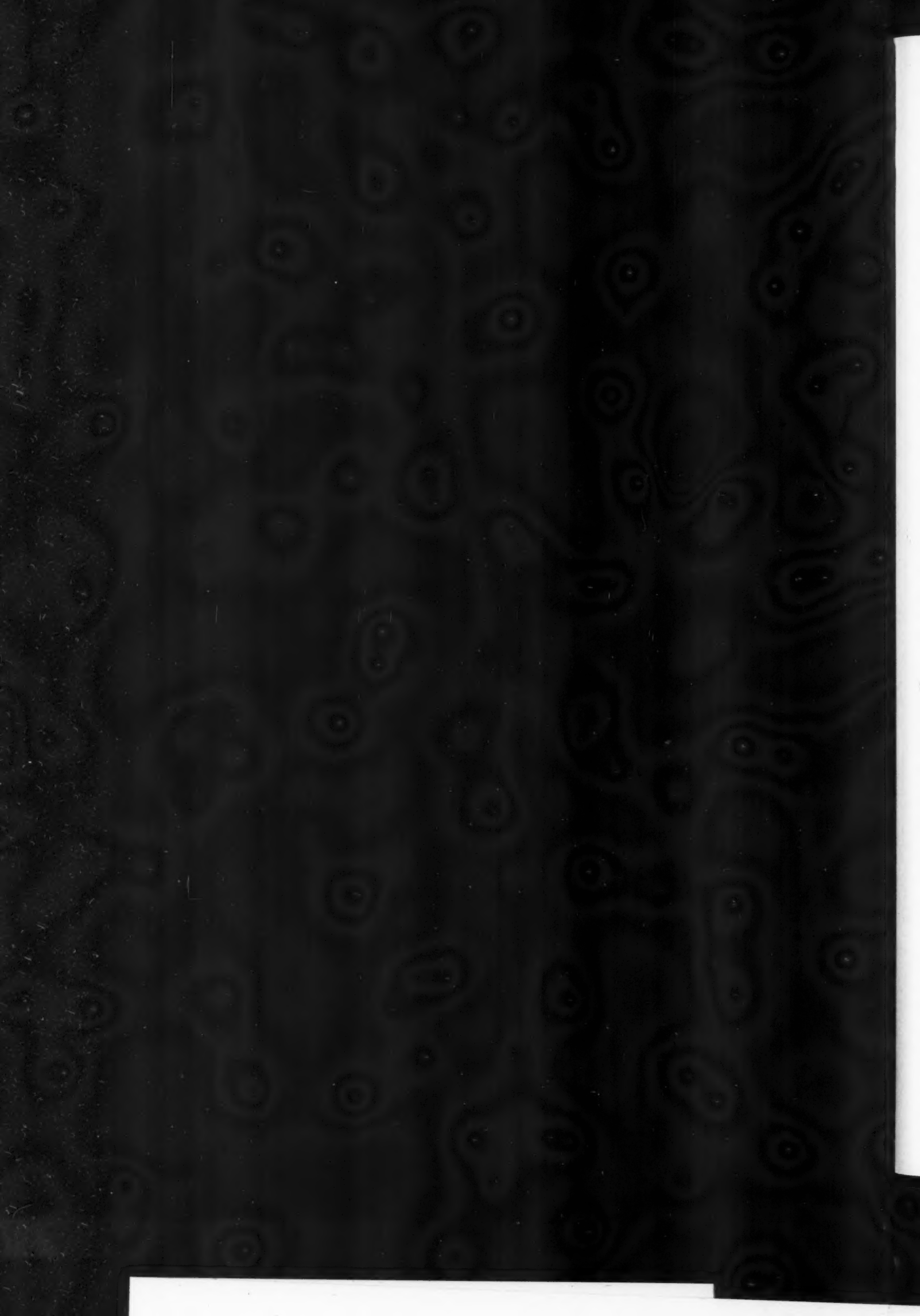
Over 1,100 lin.ft. of tunnel and 150 ft. of construction shaft were required for the circulating-water system, together with gatehouses and a large screen and intake chamber below the condensers and pumps in the turbine room. This location of the traveling screens was decided upon because it saved excavation, permitted the use of the overhead crane for lifting the screens for inspection or repair and gave better operating supervision than if located at the tunnel mouth. These tunnels have 10 ft. inside diameter, a minimum thickness of concrete lining of 12 in. and an average thickness of 18 inches.

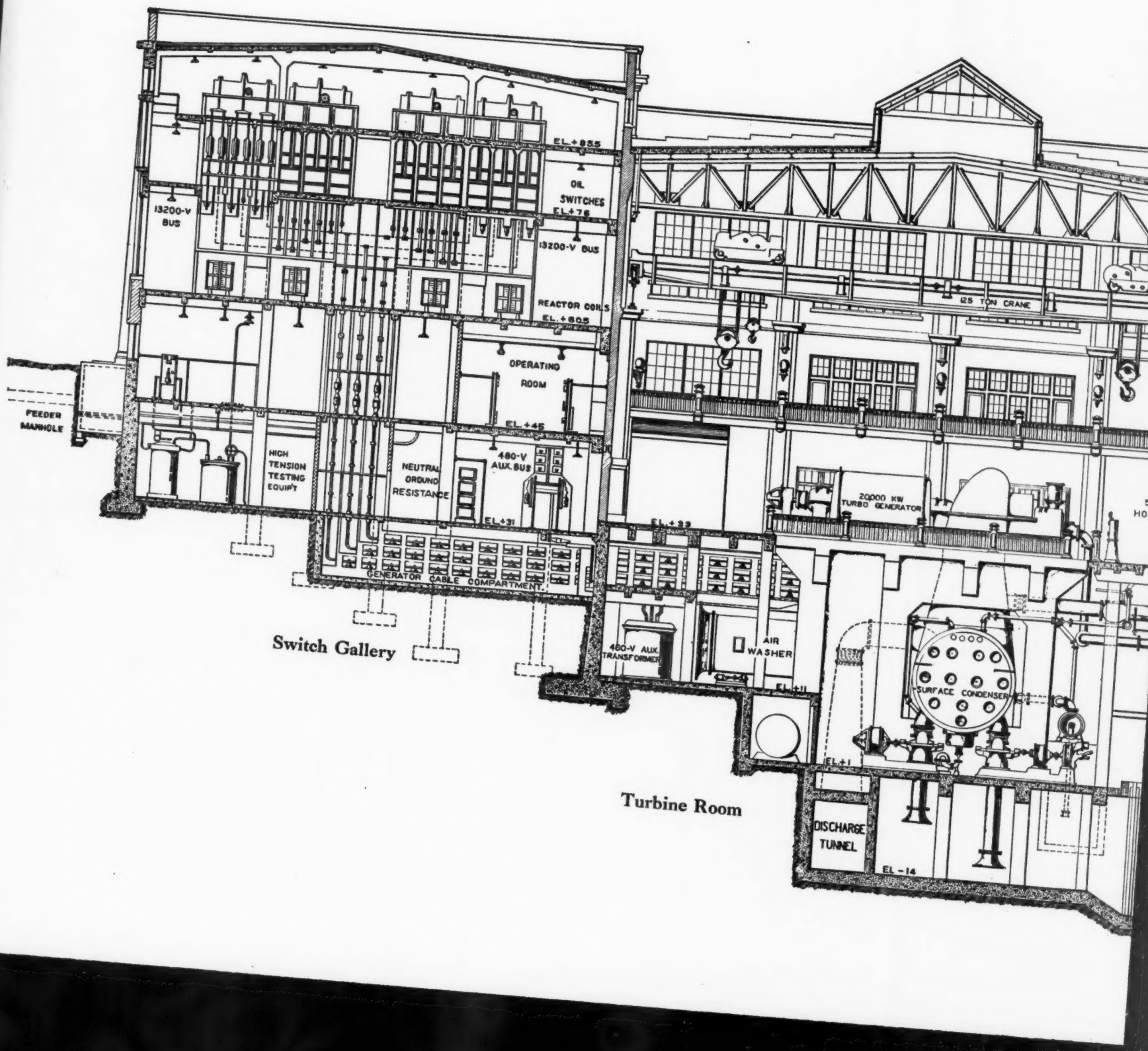
The intake tunnel, which has its top 5 ft. below the water level, is terminated about 50 ft. beyond the water line at the lake shore, and a channel was dredged out 15 ft. in depth, leading up to this tunnel, which required approximately 7,000 cu.yd. of dredging by dipper dredge. The tunnel is protected at the lake end by a timber ice boom, a submerged sheet-pile weir having its top 5 ft. below the surface, and a steel-bar screen with 6-in. spacing. Inside the plant the circulating water passes through revolving screens having ½-in. mesh, into a large suction chamber between the foundations of turbines Nos. 1 and 2.

Efficiencies Obtainable

Delay has been made in the publication of details of design in the hope that average operating figures, which really determine the status of a plant, might be incorporated. At the present writing such data are not available. As an indication of what is possible under favorable conditions the summary of fifteen tests in the accompanying table, presented before the Association of Edison Illuminating Companies, is reproduced. The tests were run by the United States Bureau of Mines for the Combustion Engineering Corp., and were all supervised personally by Henry Kreisinger. The high efficiencies given are credited to the fact that with powdered coal the proper ratio of air to coal can be maintained easily, so that there is small loss due to excess air and practically no loss from incomplete combustion and combustible in refuse.

Tables of the properties of steam (steam tables) may be arranged to have the temperatures go up by even degrees starting at 32 deg. F. or the pressure by even pounds starting at 1 lb. absolute. At higher pressures the "pressure" table can be read more closely, while the "temperature" table is more suitable for low pressures. This is easily seen from the fact that the temperature at 1 lb. absolute is 102 deg. F., while at 2 lb. it is 126 deg. F., a difference of 24 deg. for 1 lb. pressure difference. At a pressure of 200 lb. absolute, on the other hand, an increase of 1 lb. increases the temperature from 381.9 to 382.3, a difference of only 0.4 deg. As far as closeness of reading is concerned, the two tables are on a par at pressures around 67 lb. absolute, where a 1-lb. change in pressure corresponds to a 1-deg. change in temperature.

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REACTOR COILS
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OPERATING ROOM
EL.+45
FEEDER MANHOLE
HIGH TENSION TESTING EQUIP'T
NEUTRAL GROUND RESISTANCE
480-V AUX. BUS
EL.+31
GENERATOR CABLE COMPARTMENT
Switch Gallery
125 TON CRANE
EL.+33
20000 KW TURBO GENERATOR
480-V AUX. TRANSFORMER
AIR WASHER
EL.+11
SURFACE CONDENSER
EL.+1
DISCHARGE TUNNEL
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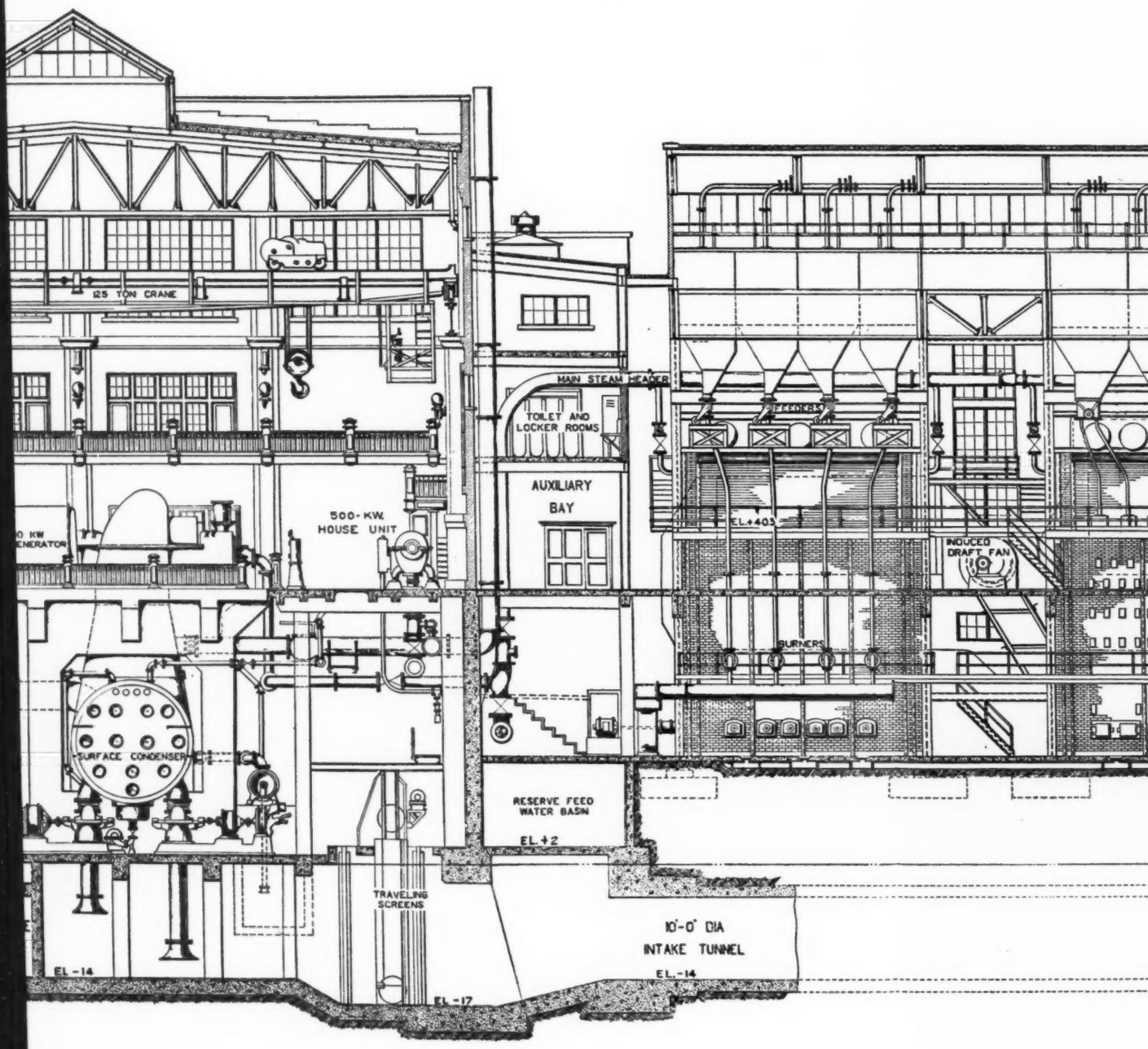

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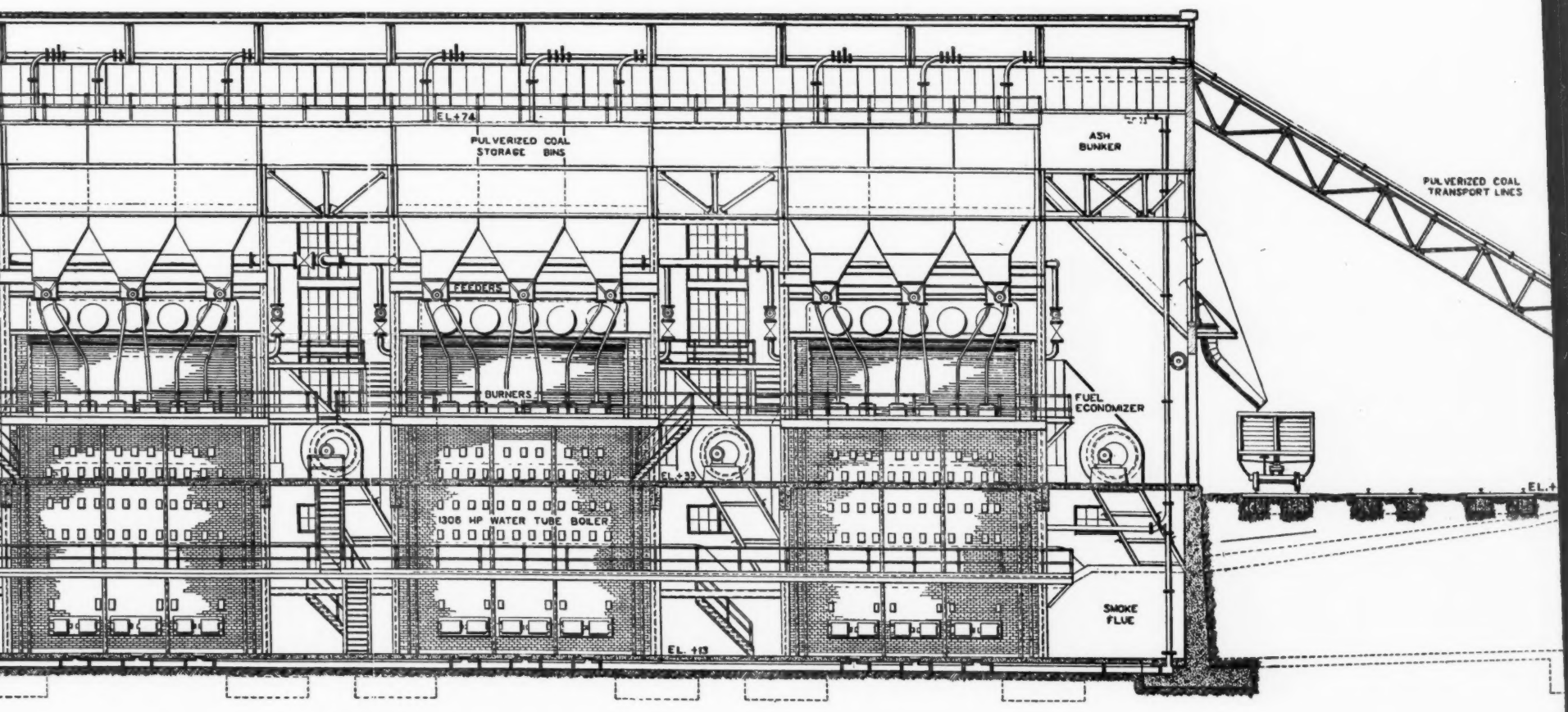
Exclusively by Pulverized Coal

Initial Rating, 40,000 Kw.
Ultimate Rating, 200,000 Kw.



Boiler Room

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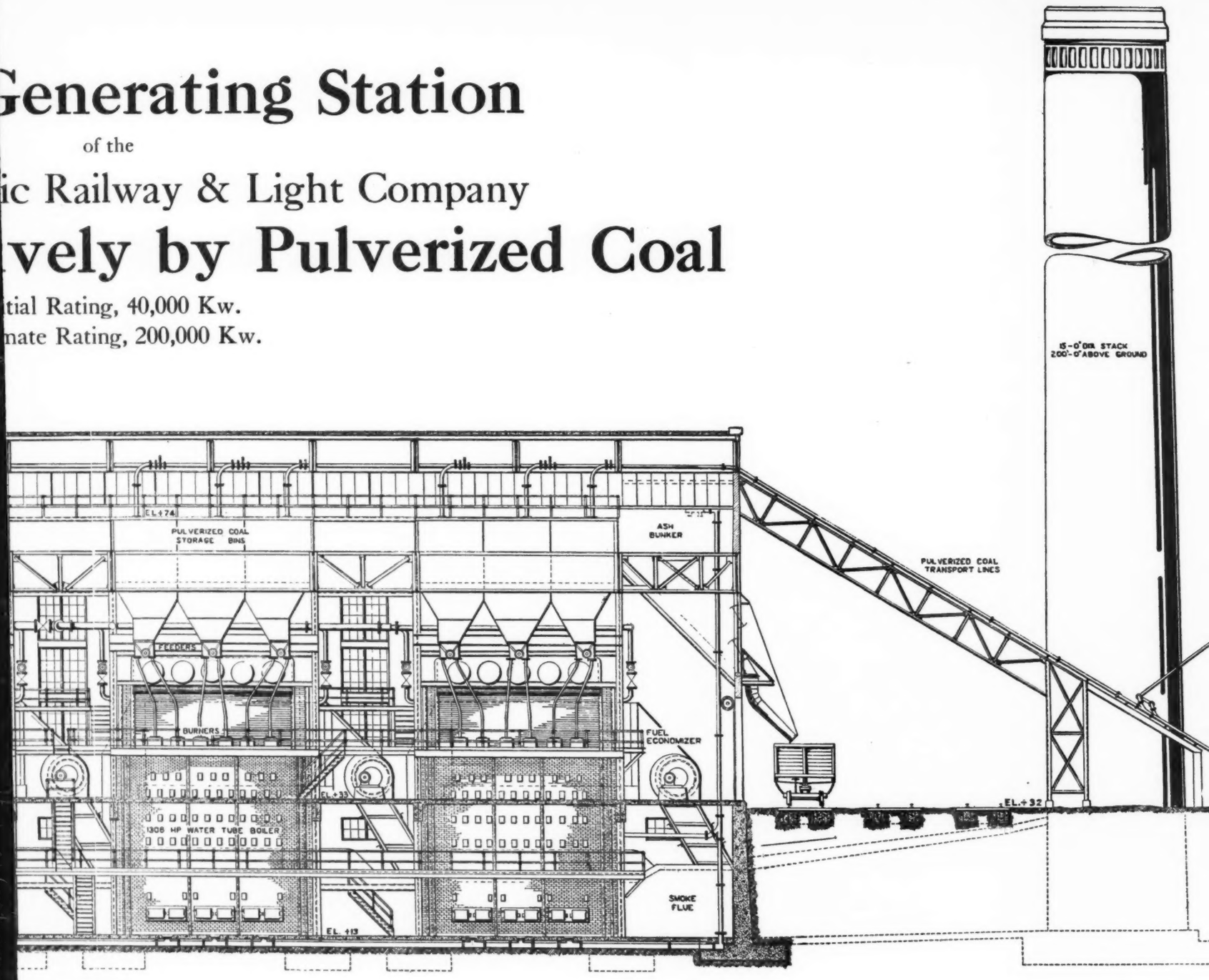

Boiler Room

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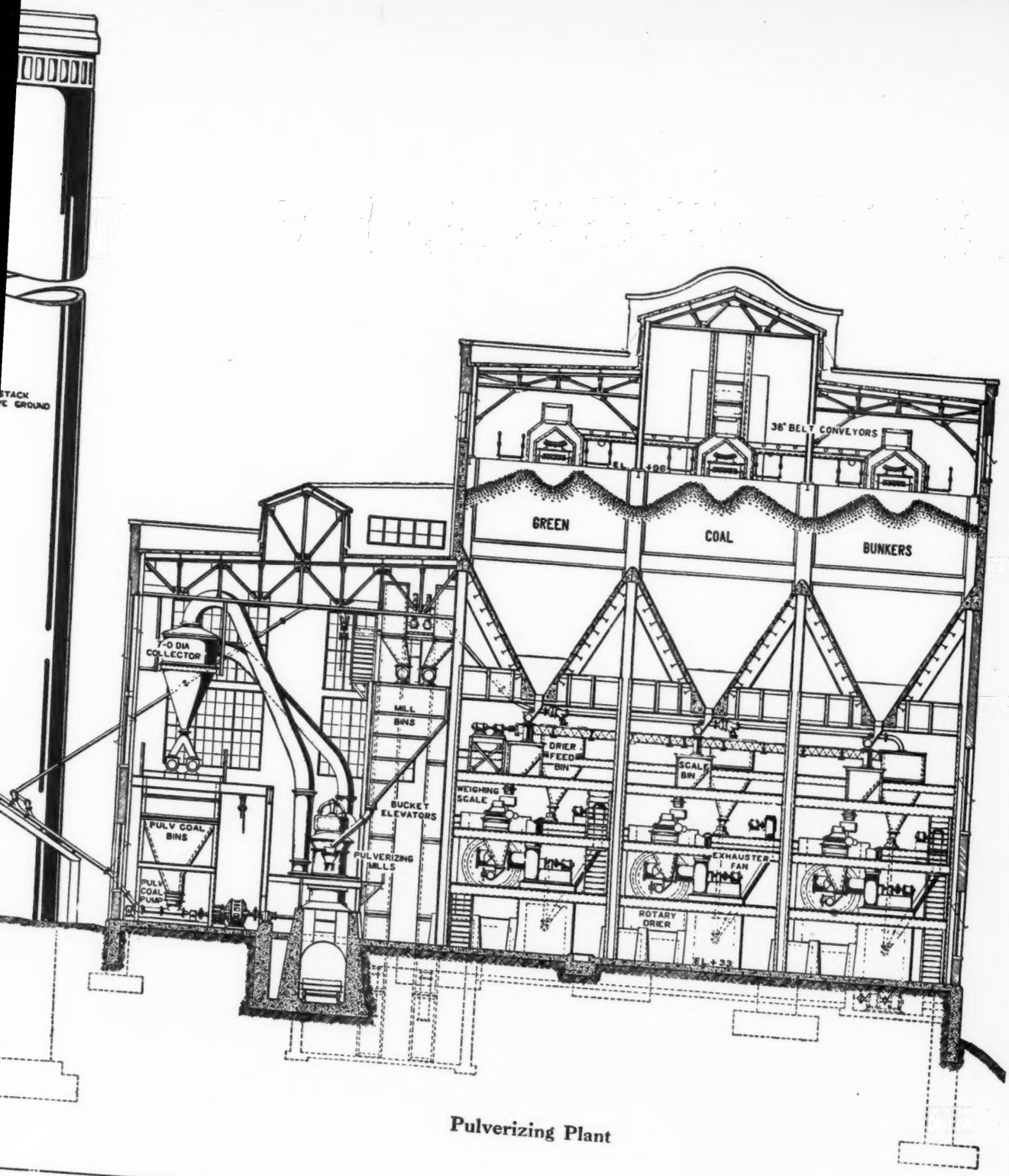
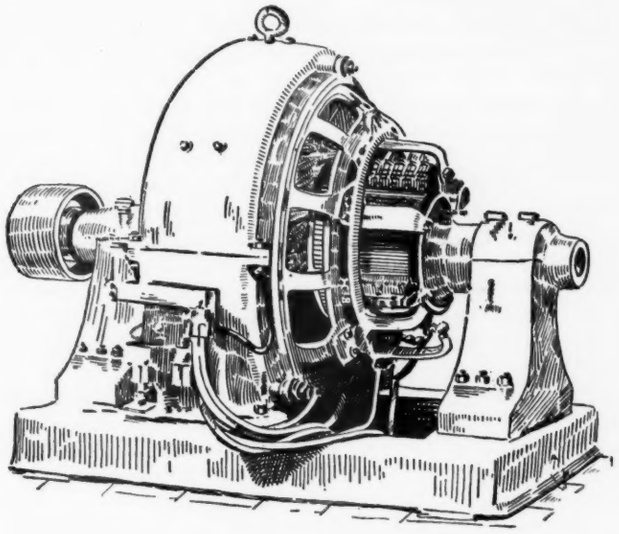


Pulverizing Plant

Application of Electric Motors



ELECTRICAL characteristics of the various types of motor explained, with view to their selection and adaptation to specific purposes.

BY GORDON FOX
Electrical Engineer, Freyn, Brassert & Company, Chicago, Ill.

FOR direct-current service the shunt-wound motor is the prevailing type. This motor has a constant-speed characteristic and is well suited for the majority of constant-running machines, particularly where the load is of a generally uniform character. The standard shunt-interpole motor is susceptible to speed adjustment by field rheostat to about 115 per cent of rating, and often more than this is permissible, if desired, particularly with the lower-speed ratings. A somewhat special type is the compensated motor, which is particularly adapted to fluctuating loads. In most cases the adjustable-speed motor is of the shunt-wound type, giving a maintained speed at any rheostat setting over its range.

COMPOUND MOTORS ARE PREFERRED FOR MANY APPLICATIONS

The compound motor is more or less a special-purpose motor. The additional complexity of the field winding must be justified by a particular need. It is applied particularly to secure high starting torque per ampere input, such as is required for hard starting or high-inertia machines, for starting small motors without resistance, or to obtain a drooping-speed characteristic as for flywheel applications.

Where voltage is subject to fluctuations, the compound winding tends to improve speed regulation and commutation, and is adaptable, for instance, on mine or electric-railway distribution systems. Where the load increases rapidly with the speed, the compound motor may be used to protect itself through its drooping-speed characteristic, as in driving a centrifugal fan. It is adaptable also where a series characteristic is desired, as in service involving starting, stopping and reversing, yet where it is desired not to exceed a stated speed when running under a light load; where a slow-down is desired in connection with constant-speed running the addition of a series field to a shunt motor renders the slow-down more effective; where motors are to be operated in parallel, requiring a drooping-speed characteristic; where a series characteristic is desired in connection with dynamic braking. In this case sufficient shunt field is required to provide the braking field. By this it is meant that where a series motor would be desired except for the fact that dynamic braking is necessary, a compound-wound motor is supplied having sufficient shunt field for the braking duty. The amount of dynamic braking obtained depends upon the field flux and the armature current, so that a fairly stiff field reduces the braking current. For this reason it is desirable to have sufficient shunt field so that no-load speed is about 150 per cent of full-load speed.

COMPOUND MOTORS OF CUMULATIVE TYPE

Compound-wound motors are almost always cumulative; that is, with the shunt and series fields acting to produce the same polarity in the polepieces. The differential winding may be employed to obtain close speed regulation but the interpole motor meets every ordinary need in this respect. The degree of compounding varies. The standard, utility type of compound motor has a no-load speed about 115 to 125 per cent of full-load speed. Mill-type motors with compound windings have no-load speeds 150 to 200 per cent of full-load speed. The latter class are often termed series-shunt motors. Here the shunt winding serves the single function of restricting light-load speeds, it being too weak for effective dynamic-braking duty. A motor of this type would have a light shunt field and would have a no-load speed of about 200 per cent full-load speed. At the present time a considerable number of motors of this type are used for dynamic-braking duty, but excessive armature currents are required to get the desired braking torque.

Of the series motor the predominant characteristics are slow speed and high torque on heavy loads, with the speed increasing under the lighter demands. This characteristic fits this type of motor particularly for duty involving frequent and severe starting or reversing and in general where high torques are necessary. Railway and crane motors are largely series wound, and frequently mill-type motors are also of this class. The series motor has a measure of advantage in that its field coils are made up of heavy wire or strap, minimizing troubles at this point. It has preference over the shunt or compound motor where current collectors are involved, since a minimum number of collector rails or bars are required and there is no danger of excess speed due to interruption of the field circuit.

APPLICATIONS OF SERIES MOTORS

The inverse-speed characteristic of the series motor is of value in crane service in that heavy loads are necessarily handled at low speeds whereas the crane will make its light trips at a much faster rate. The series

motor is used quite extensively in small sizes for starting without resistance, particularly where the load will naturally restrict the speed closely, as for fan drives. Series motors will run away if all load is removed, therefore they should not be used for belted drives or where the load may be removed through a clutch or other devices. As the speed varies with and depends upon the load, the rated full-load speed is merely nominal. The actual load in each case must be determined and used as a basis for computation of motor speed and resulting machine speed.

In industrial service alternating-current motors greatly outnumber direct-current motors, the ratio being about 3 to 1. The great majority of these are induction motors and about 90 per cent are of the squirrel-cage design. The familiar squirrel-cage motor has a constant speed characteristic similar to that of the shunt-wound direct-current motor. It is pre-eminently suited for continuous-running drives having no exceptional requirements. The squirrel-cage motor with high-resistance rotor is adapted for high torque, intermittent duty such as elevator service. The drooping-speed characteristic obtained with motors of this type fit them for use with flywheels. The high-resistance squirrel-cage motor is being used to some extent in connection with primary resistance for high-torque starting duty or to obtain a small degree of speed regulation. One of the principal difficulties is the dissipation of the rotor losses if the service is at all severe or continuous.

High-Resistance Squirrel-Cage Motors

With reference to the high-resistance squirrel-cage motor it might be mentioned that the ordinary squirrel-cage motor develops relatively low starting torque. An increase in rotor resistance increases the starting torque, and by suitable rotor design it is possible to obtain a motor that will develop maximum torque at standstill. If a motor of this type is operated in connection with primary resistance, it is possible to obtain characteristics similar to those of a wound-rotor motor. Further, wound-rotor motors are commonly supplied with starting resistances such that they do not develop maximum torque at standstill, but increase the torque as the resistance is cut out. In a similar manner, squirrel-cage motors with high-resistance rotors may have primary resistance installed to cut down the starting current and also cut down the torque at starting, and this torque may then be increased by cutting out the primary resistance. This practice is followed in some crane controls, because collector bars are eliminated as only the three primary connections need be made to the motor. This method is also used in connection with two-speed motors for skip hoists and alternating-current high-speed elevators. Where the primary is wound for two speeds a squirrel-cage rotor has marked advantage in the matter of simplicity. In order to meet the high starting-torque requirements a high-resistance rotor is used. In order to prevent excess current inrush and too sudden starting jerks, resistance is first inserted in the primary circuit and then reduced. This resistance also serves the function of minimizing the current at the instant the motor is thrown over from one primary connection to the other.

Like its compound-wound direct-current prototype the wound-rotor induction motor is a special-duty machine. It is adapted to frequent or severe starting duty or where it is desired to minimize line disturbance as it can develop high starting torque per ampere. It can be used to obtain some degree of speed adjustment and control, similar to that obtained with the direct-current motor with armature resistance. The latter characteristic fits this motor fairly well for regulation of speed of uniformly loaded machines such as pumps and fans. This motor is also used, with manual control of secondary resistance, for manipulating drives such as crane hoists, mine hoists, mill tables and traction. Although admittedly inferior to the direct-current motor in electrical characteristics, the wound-rotor motor reaches a high degree of success in many of these installations. It may be used also in connection with flywheels, particularly in the larger sizes, where adjustable secondary resistance permits the most effective application. The wound-rotor motor is rapidly developing, in the larger sizes, as an adjustable-speed drive in connection with auxiliary machines connected in the secondary circuit. Such motors afford a speed range from about 30 per cent below synchronism, with constant speed or drooping regulation as desired, at any setting. This motor is employed also to a small extent in cascade with another induction motor to give a selection of speeds.

The multi-speed motor is simply a special type of induction motor having the primary windings arranged to give two or more pole groupings for two or more different synchronous speeds. The secondary may be either squirrel-cage type or phase wound. The squirrel-cage type is to be preferred because of its simplicity. Multi-speed motors may be rated to develop the same horsepower at different speeds or to develop constant torque with a higher horsepower rating at the higher speed. The characteristics of the load must be considered in suiting the rating to the application. The more common speed ratios are 2 to 1, 3 to 1 and 4 to 1, although higher ratios are occasional. The multi-speed motor finds a number of applications where two running speeds will suffice in lieu of adjustable-speed drive. It is also meeting with some favor for semi-manipulating service; for instance, on elevators and skip hoists, where the high speed is used for running and the low speed for making landings. The high-resistance squirrel-cage motor is used in some of these applications. In the absence of an adjustable-speed alternating-current motor there appears to be a tendency toward further development and application of the multi-speed motor, particularly for special applications.

Synchronous Motors Gaining in Favor

Because of its high power factor and its corrective possibilities, the synchronous motor is steadily gaining favor. It is adaptable only for constant-speed drives where starting is infrequent. Through use of auxiliary squirrel-cage windings fairly good starting characteristics are now attained, motors being available that will develop 65 to 75 per cent full-load starting torque with 250 per cent full-load kilovolt-amperes. In connection with self-starting synchronous motors, both static and pull-in torques must be considered. In some cases magnetic clutches are employed to good advantage to permit the motor to start light, the load being applied after speed has been attained. Synchronous motors of high-speed ratings have not been extensively applied. They have particular advantage in the larger sizes and at the lower speeds, where the first cost compares favorably with that of the induction motor and the efficiency and power factor are both better.

In the application of synchronous motors it is advisable to investigate the possibility of using an oversize

motor to obtain the maximum advantage as a synchronous condenser for power-factor correction. A slight disadvantage of the synchronous motor lies in the fact that it may fall out of step through line disturbance or momentary interruption of power; also it adds to the amount of synchronous apparatus upon a system which will feed into a short-circuit. Synchronous motors are sometimes of particular advantage when connected to long transmission lines, in their improvement of voltage regulation.

This discussion would not be complete without some remarks concerning alternating-current versus direct-current motors. For continuous-running constant-speed drives, both alternating and direct-current motors may be obtained, giving closely parallel performance. For most other classes of service the characteristics available with alternating-current motors differ to a greater or lesser degree from the characteristics available with direct-current motors. Induction motors are restricted to definite synchronous speeds, whereas direct-current motors may be designed for any speed desired.

In general the direct-current motor offers a wider selection of inherent performance, characteristics and greater possibilities for flexibility in control. Direct-current magnetic control is often more simple and is more highly developed than that for the alternating-current duty. There is a distinct field, where performance and controllability are of first importance, where direct current is usually warranted and to be preferred. The extensive use of alternating-current motors is due primarily to the fact that power is more commonly available in that form. For like reason the induction motor and synchronous motor are being constantly improved. But the direct-current motor continues to hold a well-deserved preference for specific purposes. Each type has its field, the proper decision depending upon the requirements of the particular case.

A second article will discuss factors affecting motor application, such as, voltage, speed, efficiency, power-factor, basis of rating and local conditions influencing the selections.

A Few Notes on Film Lubrication

By W. F. OSBORNE*

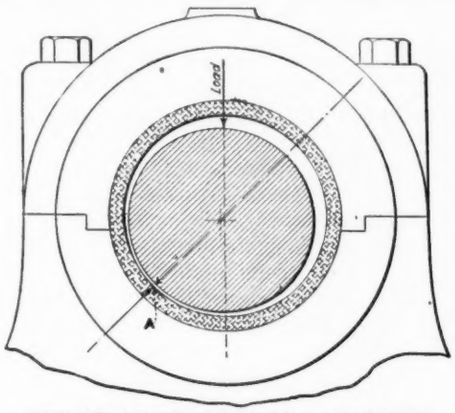
THE purpose of all lubrication is to reduce mechanical frictional loss and wear. It is accomplished by placing between the moving surfaces a substance whose friction is less than that of the surfaces requiring lubrication. It makes but little difference what the lubricant is—air, water, soap, oil, graphite or what not—so long as it keeps the moving surfaces from touching and has in itself a lower frictional resistance than that of the moving surfaces.

Frictional losses are reduced in two ways—by means of a film of lubricant completely separating the moving surfaces, or by filling the minute irregularities of the surfaces, smoothing them up and enabling them to slide over one another more easily. The former method will be the subject of this article.

Referring to the illustration, which shows a cross-section of a journal bearing with an exaggerated clearance, suppose that the clearance is completely filled with oil and the journal is rotating in an anti-clockwise direction. The adhesion of the lubricant to both bearing and journal will produce a wedging action as the oil is drawn under the journal at *A*. This will raise the shaft from the bearing and cause it to float on a film of oil in some such position as shown. The influencing factors in the formation of this film of oil are viscosity, journal speed, load, amount of lubricant in the bearing, pressure of oil to bearing, shaft diameter, bearing clearance, bearing length, smoothness of journal and bearing surfaces and the position of the load with respect to the center of the bearing.

Without going too extensively into the mathematics of bearing lubrication, which has been worked out in an excellent paper by M. D. Hersey and published in the "Transactions of the A. S. M. E." for 1915, we can say that increasing the absolute viscosity of the oil will raise the total friction of the bearing, everything else, including the clearance, remaining constant. For concentric bearings or journals running at such high speeds that the journal is very nearly concentric with the bearing, the friction undoubtedly is proportional to the absolute viscosity of the oil. This would seem to indicate that we should use the lowest viscosities that will produce a satisfactory film. A heavily loaded bearing, in which the clearance *A* is very small, however, might have its friction reduced by the use of a high-viscosity oil, on account of the increased wedge action tending to raise the journal off the bearing.

The effect of a heavy load in increasing the frictional losses in such a bearing is due only to its influence in reducing the clearance at *A* and is noticeable principally



EFFECT OF OIL FILM ON A BEARING

at speeds low enough to produce a very eccentric bearing. As a matter of fact, the higher the speed the greater will be the load-carrying capacity of a bearing lubricated on this principle.

For a concentric bearing an increase of speed will increase the rate of shear of the oil film and thereby raise the total frictional loss. However, it also increases the wedge action of the oil, which in turn increases the clearance, a condition that helps to balance conditions, particularly under heavy loads.

When oil is fed into a bearing under pressure at the point of least clearance, it will tend to raise the shaft,

*Supervisor, Manufacturers' Service, Texas Co.

increasing the clearance and thereby decreasing the frictional losses. Obviously, this method is adaptable only when force-feed systems are used and the pressure in the oil line is greater than that in the clearance space.

For a concentric bearing the frictional resistance varies inversely with the bearing clearance, or the difference in diameter of journal and bearing, because for constant surface speed, when the film is reduced in thickness, the rate of shear increases. Large clearances will decrease frictional losses and temperature; small clearances will increase them. It should be remembered, however, that this statement does not apply for low-speed bearings under heavy loads, as the velocity of the shaft is not great enough to overcome the tendency of the heavy load to squeeze out the oil when the clearance is large.

Frictional Resistance Varies with Length of Bearing

The total frictional resistance will vary with the length of a bearing, but if the load is the same in each case, the load per square inch will be reduced for the longer bearing. This in turn increases the clearance at *A* in the illustration and decreases the frictional loss.

Generally speaking, the smoother the surface the less will be the interruption in the stream-line flow of the lubricant through the bearing, and the frictional losses will be reduced accordingly.

One very important thing to remember in connection with these statements is that they are all based on the assumption that an ample supply of oil is furnished to the bearing. It makes no difference how it is delivered, ring oiler, force feed, gravity feed or splash, so long as enough oil is fed into the bearing to keep the clearance space between the journal and bearing completely full. Then, if the principles outlined here are carefully followed, the best of lubrication should be secured.

From this discussion we find that the only property of an oil which has anything to do with preventing the journal and bearing from rubbing is the property called viscosity. When we say viscosity we mean absolute viscosity, not Saybolt or Engler viscosity. In other words, if the viscosity is right, not too high nor too low, taking everything into consideration, the journal can be operated at minimum frictional losses and temperatures. As far as maintaining the oil in its original condition is concerned, or reducing evaporation losses, etc., there is an entirely different story to tell. These are all factors that come under the general heading of quality, and must be determined by tests that have no bearing on the reduction of frictional losses, except in so far as they affect the maintenance of the original viscosity of the oil in service.

Lubricating Value Defined

Q. What is the meaning of lubricating value, and is it possible for one oil to possess more units of lubricating value than another?

A. Lubricating value is a pretty hard thing to define. When we consider the question of reducing friction in a bearing lubricated by the film method, apparently the only physical property of the oil that has any influence is absolute viscosity. When an insufficient amount of oil is available and an imperfect film is produced with consequent partial rubbing of the journal and bearing in actual metal-to-metal contact, it is possible that the chemical constituents of the lubricant may have some effect in reducing friction. Some investigators have found an apparent difference in the lubricating qualities of oils of exactly the same viscosities and have called this apparent property, "oiliness." It probably has no effect except when imperfect films are formed, and no clear understanding of just what occurs has been arrived at.

When the claim is made that an oil contains so many units of lubricating value, it is probably just sales talk and doesn't mean anything. Units of lubricating value are not actual physical quantities which can be added to or removed from any oil. Lubricating value is the general all-around suitability of an oil for the purpose in view, taking into consideration its friction-reducing qualities, length of life and permanency of character.

A Simple Method of Expressing Long Numbers

Instead of writing 100, we may write 10^2; instead of 1,000, 10^3, etc.; 1,000,000,000, for instance equals 10^9.

The velocity of light is 186,000 miles, or about 982,000,000 feet per second, or 300,000,000 meters per second. These values may be expressed thus:

$$186{,}000 = 186 \times 10^3 \text{ miles per second.}$$
$$982{,}000{,}000 = 982 \times 10^6 \text{ feet per second.}$$
$$300{,}000{,}000 = 3 \times 10^8 \text{ meters per second.}$$

The method is obviously good only for numbers ending with a string of ciphers and consists of multiplying that part of the number before the ciphers by 10 with the number of ciphers as an exponent.

A minus exponent means that unity is to be divided by the power indicated. For example, 4^{-2} means that 1 is to be divided by 4^2, or $\frac{1}{4^2} = \frac{1}{16}$. In other words, the minus exponent indicates the reciprocal of the power. Then

$$10^{-3} = \frac{1}{1{,}000}, \text{ or } 0.001$$

$$10^{-11} = \frac{1}{100{,}000{,}000{,}000}, \text{ or } 0.00000000001$$

Notice that the exponent is the same as the number of ciphers when the value is written as a vulgar fraction, but the same as the whole number of places when it is written as a decimal.

The coefficient of expansion of steel is $0.0000065 = \frac{65}{10{,}000{,}000} = 65 \times 10^{-7}$. There are seven decimal places in 0.0000065, or seven ciphers in 10,000,000; hence the minus exponent is 7.

The diameter of the hydrogen atom is about two-hundredths of a millionth of a centimeter; 0.00000002 cm. $= 2 \times 10^{-8}$ cm.

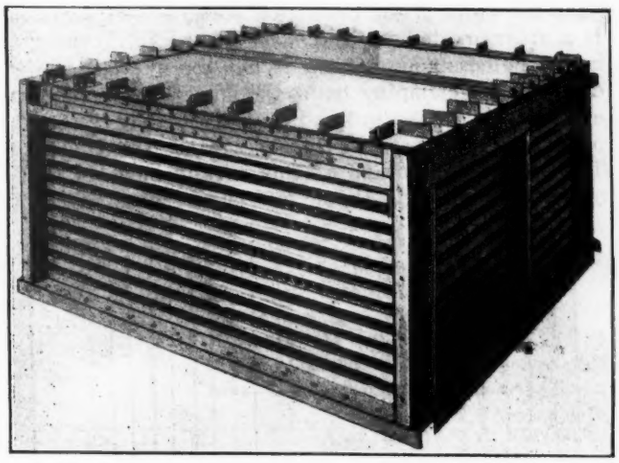
A micron, or micro-meter, equals one-thousandth of a millimeter = 0.001 mm.

A milli-micron, or micro-millimeter, equals one-thousandth of a micron, or one-millionth of a millimeter = 0.000001 mm.

The diameter of the hydrogen atom is about two-tenths of a micro-millimeter, or $0.2 \times 0.000001 = 0.0000002$ mm. $= 2 \times 10^{-7}$ mm.

The diameter of the electron is about one one-hundred-thousandth as large as this, or 0.000000000002 mm., or 2×10^{-8} mm.

European Preheater for Furnace Air*



EUROPE, which has lagged behind America in many engineering developments, has taken the lead in conserving fuel by means of air preheaters. Since the practicability of preheaters for American conditions is now the subject of considerable discussion "Power" takes this opportunity to describe a type of heater that is finding extensive employment in Europe.

THE idea of using some of the heat ordinarily wasted up the stack to preheat the air to the furnace is far from new. As a matter of fact extensive tests of boilers equipped with air heaters were made in 1881 and 1882 at the chemical works of the Pacific Mills, Lawrence, Mass. These tests, conducted by J. C. Hoadley, with the assistance of Fred H. Prentiss, are reported in great detail in Vol. 6 (1884-85) of the "Transactions of the American Society of Mechanical Engineers."

No one who takes the time to look over this paper of more than 160 pages, can fail to admire the thoroughness of the experimental work. Modern boiler tests are rarely conducted with such attention to every detail that might possibly have a bearing on the results. Three horizontal-return-tubular boilers, all of the same type and size were used in these experiments. The first boiler had no air heater. The second was provided with an air heater containing 240 horizontal, 2-in. tubes 20 ft. long. Each 2-in. tube was placed inside of a 3-in. tube of sheet iron, and the latter was embedded in mortar. The flue gases passed through the 2-in. tubes while the boiler air supply was drawn through the annular spaces between the 2-in. and the 3-in. tubes.

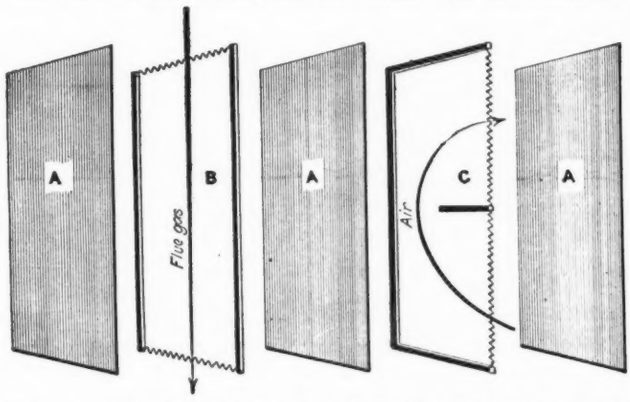


FIG. 1. HEATER PLATES AND SPACERS SEPARATED TO SHOW THE PATHS OF FLUE GAS AND AIR

As an improvement on this arrangement, the third boiler was equipped with an air heater using 2-in. tubes for the gases, but having no outer tubes. Instead, sheet-iron baffles were used to guide the air across the 2-in. tubes a number of times. The accompanying table gives some of the more important data from these tests. Mr. Hoadley reported that operation had continued without interruption or trouble of any sort from the completion of the test in 1882 until the time of writing the paper in 1884.

Largely on account of the low cost of coal, America has done little in a commercial way to exploit the air preheater, although occasional experiments have been made and the subject has been discussed from time to time. With present high fuel costs many American engineers consider the subject of air preheaters worthy of serious reconsideration. In this connection they may be able to learn something from the many users of air heaters in Europe. The price of coal being much higher there than in America, it has been necessary to give more careful attention to methods of saving fuel.

One type concerning which much information is available is the "Thermix" air heater, manufactured by Emile Prat-Daniel, of Paris. As the construction and operation of this apparatus is easily understood, it is believed that a short description will be of interest to American readers.

This air heater, as shown at the top of this column, consists of a pile of thin rectangular plates held apart by spacing frames so designed that flue gas and air may pass through alternate spaces about one inch thick. For simplicity we will call the spaces for flue gas the odd spaces and those for air the even. In operation the flue gas enters the heater on the side facing the reader and passes straight through the odd spaces to the outlet on the far side.

The air inlet and outlet may both be seen on the right face of the heater. Cold air enters the even spaces through the square opening farthest from the reader. After traveling a semicircular path, it is discharged through the nearer opening. This gives a rough approximation to "counterflow" operation and at the same time simplifies the connections.

Fig. 1 shows two adjacent elements opened up. The plates *A* are flat commercial sheets of steel about ⅛ in. thick. The spacing frame *B* for the flue-gas element is a rectangular frame made up of two light steel U-sections and two spirals of wire. The latter permit the flue gas to pass straight through in the manner shown. The spacing frame for the air element is also made of steel U-sections and wire spirals, but the arrangement is different, as shown at *C*. This forces the air to traverse a semicircular path.

The spirals are flexible and have a diameter greater

*Air preheating has been discussed in the following recent issues of *Power*: Nov. 29, 1921; Feb. 21, Feb. 28 and April 4, 1922.

than the width of the U-sections. The left half of Fig. 2 is a diagram showing the shape of the spiral when the heater is loosely assembled. When the nuts are screwed down on the clamping bolts, the spirals are compressed as shown in the right-hand diagram of Fig. 2, and the plates are thus pressed tightly against the U-sections. The obvious advantage of this arrangement is that it makes it a relatively simple matter to replace one of the

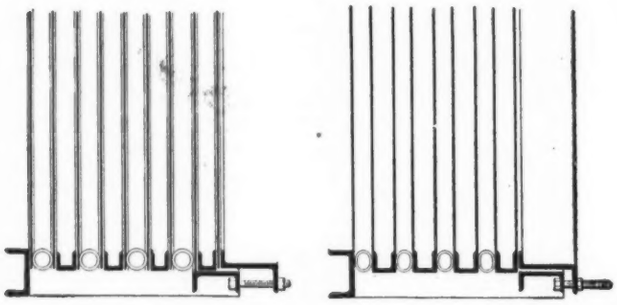


FIG. 2. ASSEMBLING THE THERMIX AIR HEATER

Left — Plates and spacers loosely assembled. Right — Stack pressed tightly together by screwing up on nut. This compresses the spirals to the elliptical section shown, and reduces the space between plates to the thickness (approximately one inch) of the solid portion of the spacing frame.

steel sheets. It is claimed that the leakage is small, because the spirals transmit the pressure uniformly.

Fig. 3 shows the heater installed in a water-tube boiler between the economizer and the point where the gases leave the boiler tubes. It is intersting to note how small the air heater is in comparison with the economizer. The path of the gas is indicated by the waved solid arrows, and that of the air by the dotted arrows. In this case the path of the gases is somewhat different from that in the heater just described. There are, in fact, a number of different arrangements as far as the path of the air and gases is concerned.

On the basis of using one apparatus or the other, the makers claim that the Thermix air heater has the following advantages over a cast-iron economizer: (1) Occupies about one-sixth the space in cubic feet; (2) weighs about one-half as much; (3) easier to clean and keep in operation; (4) greatly reduces first cost; (5) free from danger of explosion; (6) efficiency not affected by the temperature of the feed water, whereas the heat recoverable by an economizer falls off with increased temperature of the water supplied.

The makers of this apparatus have made an extensive study and prepared curves from which they can determine (for a given percentage recovery) the size and total cost of: (1) An economizer used alone; (2) an air heater used alone; (3) air heater and economizer used together in various relative sizes. From these curves they draw the conclusion that the greatest commercial economy is obtained by using the combination in proper relative sizes. At the same time they claim, as already stated, that the air heater alone is superior to the economizer alone. It is also said that the combination of air heater and economizer takes less space and is cheaper than an economizer alone, assuming the same heat recovery in both cases.

In the average installation the air is preheated to about 300 deg. F., giving a theoretical recovery ranging from 5 to 10 per cent, depending on the amount of air supplied per pound of coal. It is evident that the more excess air used the greater is the normal chimney loss and the greater is the opportunity to save by means of air heaters. The makers claim that the actual gain in over-all efficiency is materially greater than the theoretical amounts mentioned. The explanation given for this is that raising the air temperature produces an actual reduction in the flue temperature instead of an increase, as might be expected. This is another way of saying that the preheating of air not only recovers some of the heat of the flue gas and returns it to the boiler, but also effects an actual increase in the efficiency of the boiler and furnace proper.

The application of air heaters is not limited to preheating furnace air. Air can be heated for various industrial purposes, such as for operating dryers and heating buildings. For such purposes temperatures much lower than 300 deg. F. can often be used. When heating furnace air, the volume heated is always somewhat less than the volume of flue gas. For such industrial uses as permit of lower air temperatures, the volume of air supplied may be several times that of the flue gas. This increases the total heat recovery for two reasons: (1) The final temperature of the air is lower, so that the mean temperature difference between the flue gas and air is increased; (2) the greater air velocity increases the coefficient of heat transfer.

SOME AVERAGE RESULTS OF PREHEATER TESTS MADE BY J. C. HOADLEY IN 1882

	Boiler No. 1 No Air Heater	Boiler No. 2 Using Air Heater with Double Tubes	Boiler No. 3 Using Air Heater with Single Tubes and Baffles
Temperature of external air, deg. F.	78	34	49
Temperature of air supplied to furnace, deg. F.	78	337	334
Temperature of gases leaving boiler, deg. F.	368	397	377
Temperature of gases leaving heater, deg. F.	....	189	164
Efficiency, corrected for differences in temperature of external air, per cent	68.9	78.2	81.4
Percentage coal saved over operation without heater	....	11.9	15.4

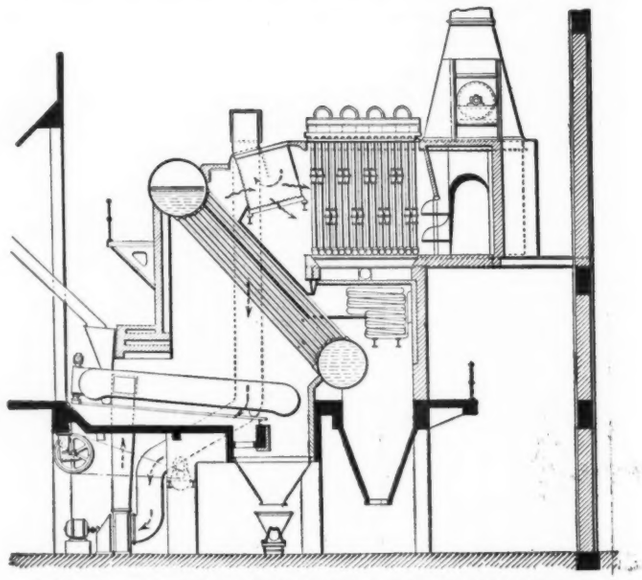


FIG. 3. WATER-TUBE BOILER USING ECONOMIZER AND 3,000-SQ.FT. AIR HEATER

The path of the flue gases is shown by the wavy arrows and that of the air by the dotted arrows.

The Thermix air heaters installed and in process of construction have a combined heating surface of more than 300,000 sq.ft. with as much as 87,000 sq.ft. in a single installation of six heaters. The majority of these are located in France. There appear to be no installations in the United States.

The Use of Water Injection in Semi-Diesel Oil Engines

By R. B. WHITE*

THE author claims that while water injection is necessary in low-pressure engines, it is not desirable and may be avoided by higher compressions. It is claimed that water does free the cylinder of carbon, and its occasional use is recommended, even in dry engines.

THE semi-Diesel engine of today is the development of the hot-bulb engine of 1895 to 1910, which operated at a compression pressure of 45 to 90 lb. per sq.in. The oil was introduced into the cylinder early in the compression stroke, since a considerable time interval was required for gasification and ignition under the low-pressure conditions. To insure ignition the forerunner of the modern semi-Diesel employed a hot bulb, which, incidentally, is used on some engines even today. The early fuel injection introduced an operating difficulty that was of vital importance. The high temperature of the bulb that was required in order that its heat might assist in the ignition, was such that on heavy loads the fuel ignited entirely too early, causing pounding. Even if ignition took place at dead center the high bulb temperature caused the velocity of the flame after ignition to be so great that heavy pressures resulted, giving rise to the pounding now termed detonation.

If the bulb was designed with a surface such that the full-load temperature was low enough to avoid preignition and detonation, the bulb temperature at low loads dropped so low that the ignition of the fuel charge did not take place or in any event was erratic and unsatisfactory.

Constant Temperature Regulation

The problem, then, was one of maintaining a fairly constant bulb temperature at all loads. To do this, the plan of introducing a small quantity of water into the working cylinder was adopted. This water, entering the cylinder at the end of the power stroke, by absorbing heat in its transformation into steam, cooled the hot piston head and, by lowering the temperature of the cylinder charge of fresh air, served to keep the cylinder and bulb temperature within reasonable limits. By varying the amount of water fed to the cylinder, the bulb temperature was held fairly steady at all loads. This made the hot-bulb engine a commercial possibility. Other claims were made for the water, it being asserted that the combustion was improved and the efficiency increased.

As the understanding of the disadvantage of low compression pressures became known, there set in a drift toward high pressures, until at present compression pressures range from 120 to 280 lb. per sq.in. The water jet, even with these pressures, which with proper cylinder design, should eliminate its necessity, is still used on many engines.

After twelve years' experience with three makes of low-compression semi-Diesel oil engines using water in the mixture and two years' experience with a medium-compression engine not using water, I have come to the conclusion that the wet-mixture low-compression type will eventually become obsolete. The dry-mixture type not only burns the fuel cleaner, but it consumes less fuel per brake-horsepower hour. Furthermore, it is not subject to racing, which is common with the wet-type engine. It has been found that the dry-mixture engine, when properly constructed, will handle a variable load successfully—in fact, all loads from no load to full load, a thing that the old-style wet type would not do. This is a decided step forward because in many industries the load is frequently all on or all off.

Automatic Water Control

Some wet-mixture engines are equipped with an automatic water feed, which apparatus puts the water into the cylinder directly in proportion to the load, and this should keep a uniform bulb temperature. Such attachments are, unfortunately, only partly successful because the amount of water required to prevent preignition also depends on the temperature of the cylinder parts. Since these temperatures do not always vary uniformly with the load, one can readily see that such attachments cannot overcome all operating conditions without the aid of a thermostat control of some kind. Even if such contrivance could be made and kept adjusted to do its part, it would only add unnecessary complications, and the purchasing public demands the utmost of simplicity in engine design. The writer doubts seriously if it can be done; at any rate it has not yet been done. A simpler and better solution is to do away with water, thus eliminating that complication.

Another reason for favoring the dry-mixture type is that such an engine can employ high enough compression to burn the cheaper grades of oil, say 26 deg. Bé. gravity fuel oil without the tarry residue usually found in the exhaust of wet-mixture engines when operating on low-grade fuel oil. By the better combustion the fuel consumption per brake-horsepower is decreased; at present a dry engine should deliver a brake-horsepower-hour on 0.5 lb. of fuel.

Advantage of Water Injection

In an experience of about 15 years handling oil engines in the field, I have on several occasions run across fuel oil that had a tendency to gum up the piston when attempting to operate without any water in the mixture, which oil would work satisfactorily when some water was fed in. In fact, cases are on record where customers purchased carloads of oil to use in a low-pressure dry-mixture engine, but could not do so owing to this gum forming on the piston, and were eventually forced to sell it to people owning wet-mixture engines, who used the same oil with good success.

There is a possibility that this gum would not form

*Anderson Foundry and Machine Co.

on engines having a comparatively high compression, say 250 or more, but if it did, the only practical solution would be to have means to feed a little water into the mixture until the customer got rid of that batch of oil. Many engineers recommend that dry-mixture engines be equipped with an emergency bleeder valve to be used in cases of this kind should it become necessary. It need not be used under normal conditions.

Owing to the fact that red-hot carbon, when in the form of amorphous carbon or soot, is acted upon chemically by steam, the product of which is water gas, there should be means to feed a little water into the mixture on dry-mixture engines at definite intervals. For instance if carbon should build up in the exhaust ports or exhaust pipe near the port, this carbon would undoubtedly get red hot under operating conditions, and if steam was passed over it, the supposition is that it would eliminate that part of the carbon that got red hot. This is another reason for equipping dry-mixture engines with emergency bleeder valves. My idea would be to operate the engine, say, 20 to 30 minutes each day with some water in the mixture for the purpose of cleansing out any red-hot particles of carbon.

Auxiliary Water Injection

We all know that water fed into the mixture is a cheap and effective way to overcome shortcomings in design, adjustment and limited knowledge of engine operators. It has been a makeshift and has served its purpose well during the period that manufacturers were gaining the necessary knowledge and experience to enable them to build a commercially successful medium-compression dry-mixture oil engine that will overcome the varying conditions in the field.

It is conceivable that under certain conditions there may be some virtues in a wet mixture as well as some well-founded objections. One should take a common-sense view and not get on either extreme, but make the very best dry-mixture engine that can be made with the present knowledge of oil-engine design and at the same time equip that engine with a bleeder valve for feeding in a little water under certain conditions.

In the early types of dry-mixture medium-compression oil engines considerable difficulty was experienced in making them operate steadily on very light loads. Multiple-cylinder engines, when the load got very light, had trouble getting all cylinders to fire regularly, thus making them waste fuel and be unsatisfactory for taking care of light-load conditions. Of recent years this difficulty has been overcome in the modern dry-mixture type of engine by means of a red-hot plug so located in the combustion chamber that when the load gets very light and the engine parts begin to cool off, the operator can direct the oil onto this red-hot plug. By putting the fuel directly onto this light-load plug, it has been found that a multiple-cylinder engine can operate successfully all day on no load. This is a step forward in the development of the dry-mixture type of engine.

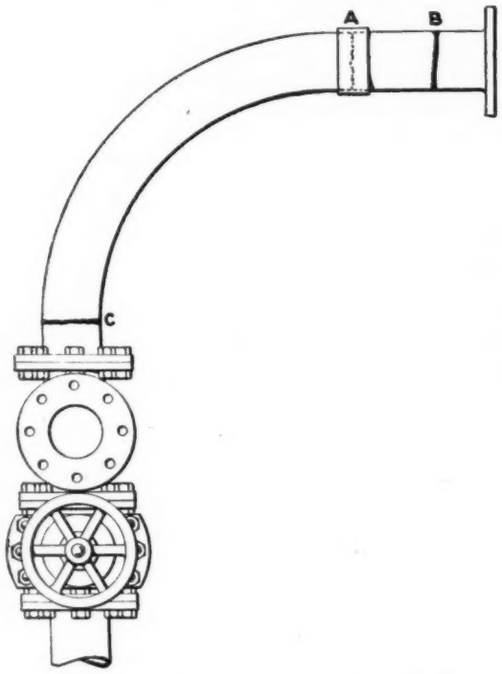
Sludging of oil in transformers not only affects the dielectric strength, but also tends to impede circulation of the oil through the windings. If the sludge is allowed to remain in the oil, there is a tendency for it to form a film over the cooling surface of the tank, as well as the windings, which impairs the radiation of the heat generated in the winding. A great deal of the so-called sludging may be eliminated by using high-grade mineral oil.

Reinforcing Weld in Steam Pipe

By A. J. Dixon

In making some changes in a 10-in. branch from the main exhaust line in a steam plant, the engineer had occasion to make three autogenous welds in sections of the pipe adjacent to a long-radius bend, as indicated at *A*, *B* and *C* in the illustration. The original position of the gate valve shown in the sketch was between the welds *A* and *B*. Its removal to the position indicated necessitated the welding in of a piece of pipe between *A* and *B* and the cutting out of a piece and rejoining of the pipe at *C*.

The oxy-acetylene welding process was used. The welds at *B* and *C* held perfectly, but the one at *A* persisted in cracking open on the under side. This weld was cut open and remade four times, but without success. The engineer ascribed its persistency in breaking open to a bending stress induced by the expansion of the curved portion of the pipe when steam was turned into it.



SHOWS WELD REINFORCED BY BAND

As a last resort he filled the fractured part of the weld with an iron cement, and a band made of a strip of mild steel about 4 in. wide and 1⅛ in. thick was put over it. A free section of 10-in. pipe was used as a form when hammering the band into shape. Opening the ends of the band, he slipped it over the weld and applied a temporary clamping band for holding it firmly in place. The edges of the band were then welded to the pipe, after which the clamp was removed and the abutting ends of the band welded together. This removed the difficulty. The maximum pressure carried by the pipe is about 6 lb. gage.

Junior members of the A. S. M. E. are now to have the privilege of voting. An amendment to the constitution allowing them to vote has been passed by more than three to one in a letter ballot, and will go into effect at the spring meeting at Atlanta, Ga.

Valves for High-Speed Ammonia Compressors

By J. H. H. VOSS*

FIFTY years ago the heavy poppet valves of the ammonia compressors were simply copies of the valves used on air compressors. With the compressors operating at 35 to 40 r.p.m., the heavy valves could easily synchronize with the movement of the piston, as is shown in all early indicator diagrams. With increased tonnage capacity the speed of the compressor had to be increased, and this resulted in more and more accidents. Efforts were then directed toward improving the construction of the heavy valve with the idea of eliminating the trouble.

Effort to Improve

The suction valve was first provided with a retaining collar on the stem to prevent the valve from falling into the cylinder in case of breakage. This, however, proved to be of no great value, for often the stem broke between this retaining collar and the disc. Second, gas cushions were adopted to alleviate the shock in opening. Such cushions made the valve still heavier in effect and interfered with its prompt action at the time of opening and closing. Next, special buffer springs were substituted, with indifferent results. In all much effort has been and still is being wasted in attempting to make heavy valves operate satisfactorily in high-speed service.

A most spectacular accident, caused by a broken suction valve, happened last September in New York City, in the Knickerbocker ice plant at Seventy-eighth Street

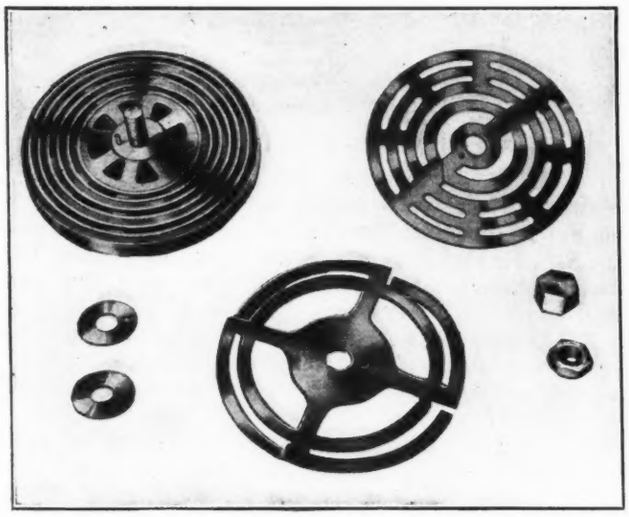


FIG. 1. INGERSOLL-ROGLER HIGH-SPEED VALVE

and East River. According to the report published in *Power* at that time, a suction valve broke just over the valve disc below the retaining collar. The heavy loss of ammonia in this accident caused quite a disturbance in the thickly populated East Side district. Fortunately, no serious consequences occurred. This is by no means the only accident that has occurred during the last twelve months, and one is quite safe in saying that the greater number of accidents to ammonia compressors have been due to breakage of heavy poppet valves, which would not have occurred if a lighter construction of valve had been followed.

The unsatisfactory results obtained with the poppet valve, especially at high speed, has resulted in the designing of light steel plate valves of various forms. Such a valve weighs from one-twentieth to one-thirtieth as much as a heavy poppet valve and can easily synchronize the piston at any compressor speed. Opening and closing quickly, it stays wide open during a longer part of the piston stroke. It admits colder and more gas than the heavy valve, it is more economical of power for its operation, and to make the measure of its benefit full, it is a perfectly safe valve, since even in case of breakage no damage can occur to the other parts of the compressor. There is not a single instance of an accident caused by a broken light valve, although when good sheet steel was at a premium during the war, broken valves were by no means uncommon. These high-speed valves have proved their economy, dependability and absolute safety at any speed.

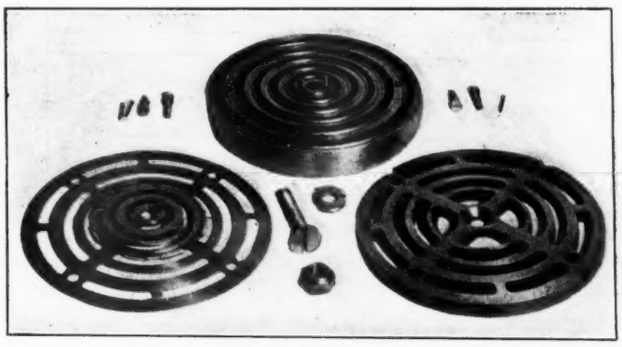


FIG. 2. MESTA HIGH-SPEED VALVE

Practical speeds observed in ammonia compressors of present design are: 240 r.p.m. for 12-in. stroke; 450 r.p.m. for 6-in. stroke; 600 r.p.m. for 3-in. stroke.

When these speeds are compared with practices of twenty years ago, one realizes the progress made in ammonia compressor construction.

Desirable Points of Construction

There are five desirable points of construction that should be incorporated in the design of every light plate valve if used on ammonia compressors. Where failures have been encountered, the valve, as a rule, has been lacking in one of these details:

1. Unrestricted movement of the light valve plate within the lift limits.
2. Maximum-effective valve area in proportion to the size of the valve body.
3. Small percentage of overlap, which calls for wide valve rings.
4. Large mass springs, in order that the springs do

*Consulting Engineer, New York City.

not tire out and respond quickly at high compressor speed.

5. Spring load to be evenly distributed over the entire valve plate.

For convenience of discussion the light valve plate will be divided into three classes, as follows: (I) Rigidly attached disc valves with integral rings connected by solid metal; (II) clamps or semi-attached

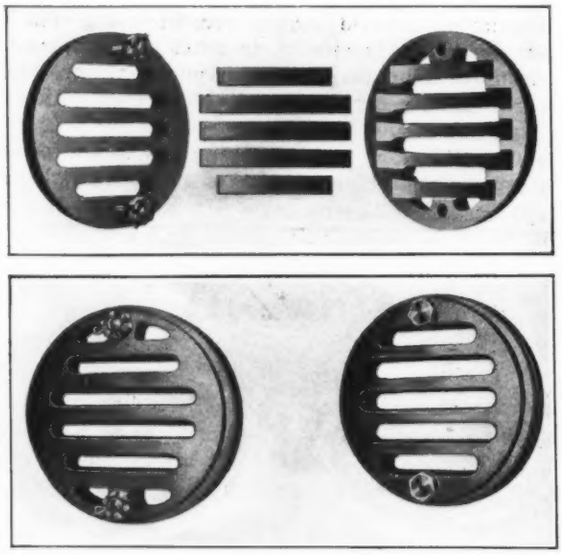


FIG. 3. WORTHINGTON FEATHER VALVE

strip or ribbon valve without spring or with superimposed bow spring; (III) unattached and independent plate valve.

Under Class I an early type of light disc valve is the Ingersoll-Rogler valve, which is shown in Fig. 1. Here the part at the upper left is the valve seat with circular port; the valve disc which is at the upper right is

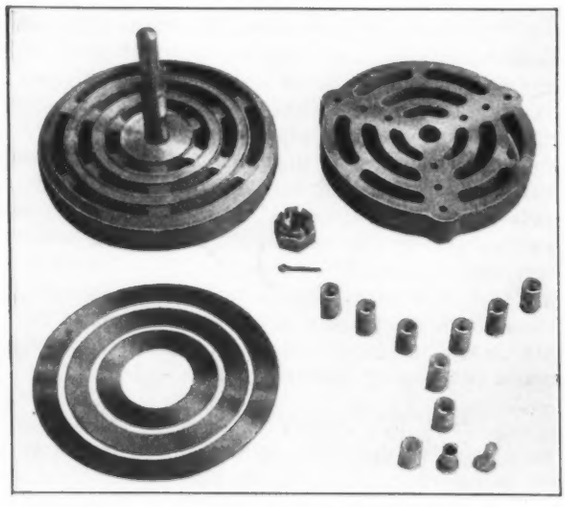


FIG. 4. SIMPLATE COMPRESSOR VALVE

machined from a solid sheet of steel. The outer portions of this disc are used as valve rings, and the inner portion is used to give the disc elasticity. The valve disc is rigidly attached to the seat by means of a center bolt. The rigid construction requires that the connection between the hub and body of the valve shall be elastic, and this restricts the lift of the whole disc, which does not exceed $\frac{1}{8}$ in., even in the large sizes. The port space covered by the elastic strip end is, of course, lost for effective passage area. The spring load on the smaller valves is produced by the bent spring arms of the cushion plate shown at the bottom of Fig. 1.

In the large valves the same general principles are used, only here a valve keeper is added to the cushion plate, and four heavy straight helical springs are used, which also press on the outer circumference of the valve disc.

Another light plate valve which has for a time been used in high-speed ammonia-compressor work is shown in Fig. 2. In this, the Mesta valve, the disc consists of integral rings connected by solid webs. One of these rings has bent-over prongs, which hold a synoidal flat central spring, which is again rigidly attached to the center bolt. The holding prongs must bend at each lift of the valve.

Under Class II of the semi-attached strip valves, one simple form is shown in Fig. 3. This is the Worthington feather valve used on the Laidlaw com-

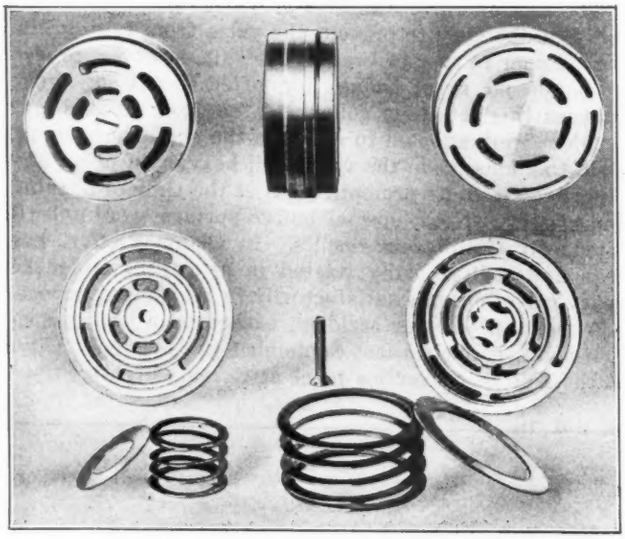


FIG. 5. VILTER RING-PLATE VALVE

pressor. Here valve feather and spring are in one piece. In opening, the feather is bowed and rests against the arched recess of the cap. In closing, the feather stretches out again and is seated by its own elasticity. The effective valve area is but slightly reduced by the space taken up by the bolt holding the valve parts together, and the valves are wide enough for a small percentage of overlap. The spring is as large as the valve strip, a very favorable proportion. The spring load is well distributed, and it is claimed that the valve closes by contact and not by impact. It must be observed that the shock on any valve comes only on opening, when the valve is smashed against the limit plate of the lift. In closing, there is no heavy shock, because at this time there is equalization of pressure below and above the valve strip.

Under Class III there are many unattached valve plates used in ammonia work. Fig. 4 shows a Simplate valve used on the Chicago Pneumatic Tool compressor. The valve seat has circular ports, and the whole space is used for effective passing area. The valve rings are simple, independently moving broad rings with a small percentage of overlap. The springs are of the

volute type made of thin strip steel, and there are three springs to each plate.

Another valve coming under this classification is the Vilter valve shown in Fig. 5 and used by the Vilter Manufacturing Co. on ammonia compressors. Here also the valve rings move independently, and the space between the valve seats is used for air passing

FIG. 6. VOSS PLATE VALVE WITH COIL SPRINGS

area. The valve rings are broad, with a small percentage of overlap. While the springs have a large mass, they are of the straight helical type which require time for responding in action; that is, the acceleration is slow. The valve has the advantage, however, that the spring rests against the entire surface of the plate, and consequently the lift of the valve should be vertical without any local bending, which often occurs where the valve is held by three or four distinct springs.

A late design of light valve plate, shown in Fig. 6, is a ring plate valve designed by the author. The valve seat has circular ports, the effective passage area is large, as the entire surface of the seat is used for valve ports, and the overlap on the valve is small. The first springs of this type had simple straight helical forms,

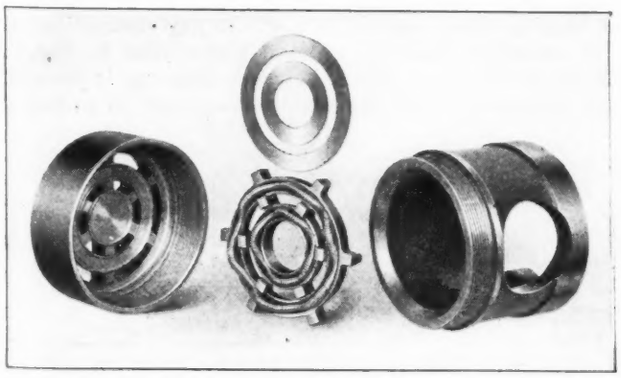


FIG. 7. RING-PLATE VALVE WITH CONTINUOUS COIL SPRINGS

which were nested in grooves and recesses of the valve keeper. The valves were set under tension in bow shape and touched the valve plate with their center part only.

A simplification in the construction of the new spring suggested itself, and a change was made by winding the bent part of the spring into a continuous coil, as shown in Fig. 7. This alteration made the assembling of the valve very easy, as the wave spring can be simply placed in turned grooves of the valve keeper. These new springs have twice the mass of metal in the separate springs of the valve in Fig. 7, and with their permanent set they have greater elasticity. Another important point is that with the wave spring the spring load is fairly evenly distributed over the entire valve plate, although the spring does not come in contact with the entire surface of the plate. The plate in consequence moves in exact parallelism with the seat, preventing binding or cocking, and it also keeps the valve plate free from bending stresses.

A late development in valve design, Fig. 8, has been brought out by the De La Vergne Machine Co. This valve consists of five prime elements—the upper half, lower half, rings, springs and bolts. It is reversible and can be used for either suction or discharge by simply reversing its position in the compressor port.

The ring plates are so arranged that they move up and down continuously in the same vertical plane and

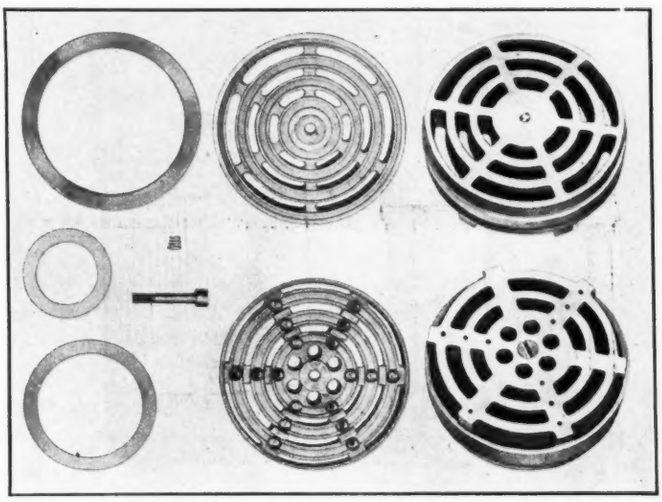


FIG. 8. DE LA VERGNE HIGH-SPEED VALVE

there is no chance for lateral movement. Each ring plate is provided with a suitable number of small helical springs. These springs are so situated that they do not interfere in any way with the passage of the gas through the valve.

With these improvements in valve design the next step that has been taken by a number of manufacturers is the improvement of the slow-speed ammonia compressor. There are in the United States thousands of slow-speed compressors that can be made to give an increased capacity by running them at a higher speed. All that it is necessary to do is to change the heavy poppet valve and put in light valves in their place. Capacity can be often increased by 30 per cent, and the compressor will be absolutely safe and also more economical in power. Of course this is all based on the supposition that the design of the reciprocating parts of the compressor will allow a higher speed than now carried. On the other hand, it is not always necessary to increase the speed of the compressor when the high-speed valves are substituted for the heavy poppet valves, since the lighter valves will operate as efficiently at slow as at high speed.

Steam-Engine Indicators Designed To Meet Special Conditions

IN STEEL rolling mills and other industries where there is an irregular load on the engine that varies rapidly and in such sequence that knowledge of the behavior of the engine could not be secured by the study of a single diagram, the demand for an indicator to meet these special conditions has led to the design of instruments that will take any number of diagrams covering successive revolutions of the engine. The usefulness of such a continuous-diagram indicator is not confined to the rolling mill, but is of extreme advantage in any steam engine or gas engine that is operating on varying loads. It furnishes recorded proof of the operation of the engine in a form that permits

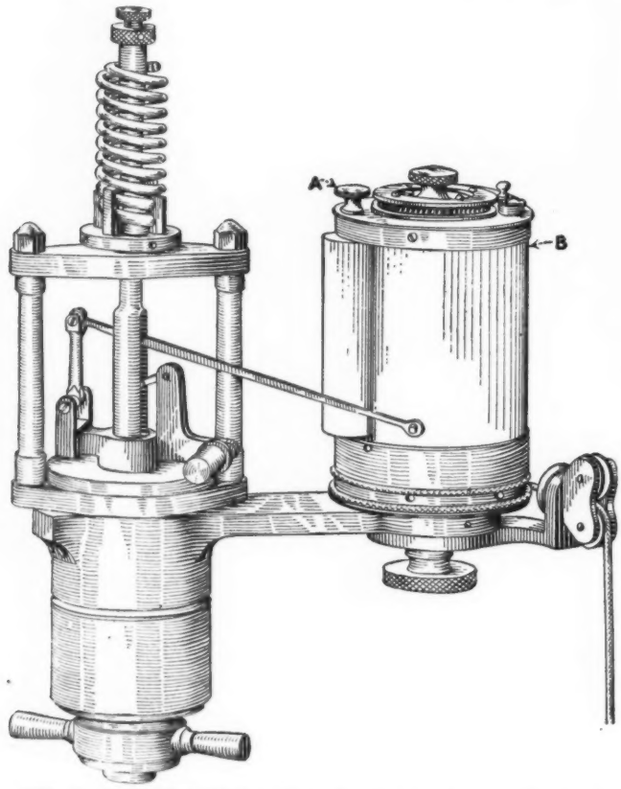


FIG. 1. CROSBY INDICATOR WITH CONTINUOUS DRUM

one diagram to be compared with another, and the variation of the load on the engine during the cycle of operation, such as rolling a billet, may be studied and the horsepower used per minute or per operation determined.

In Fig. 1 is shown the Crosby indicator fitted with a drum that will give continuous diagrams. The drum is designed to use a roll of paper 2 in. wide and 12 ft. long, which is placed on a spindle *A* as shown, within the drum and, after passing around the outside of the drum, is wound around a central cylinder within the drum *B*. This central cylinder may be withdrawn from the top of the drum and the paper attached without unwinding. Upon the top of the drum is a knurled head loosely attached to the drum spindle, which controls the spacing of the diagrams so that by adjustment they will vary in number from six to one hundred per linear foot of paper.

The Trill indicator, giving a continuous diagram, is shown in Fig. 2. This is similar to the standard piston type, but carries two drums on the bracket. One of these drums *D* holds a roll of paper 250 ft. long, and this paper is drawn onto the main drum *E* where the

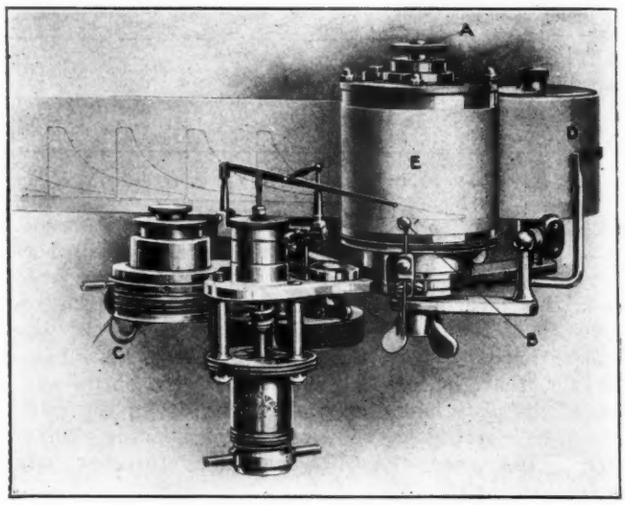


FIG. 2. TRILL CONTINUOUS-DIAGRAM INDICATOR

diagram is traced by the pencil. When the indicator is started, the paper is fed automatically onto the main drum by the movement of the drum *E*, and a new diagram is secured for each stroke of either the head or crank end of the cylinder. The paper passes off the main or tracing drum and is torn off at any desired point. The series of diagrams secured are similar to Fig. 3, where it will be observed that each diagram is distinct and complete. This enables the variation in pressure

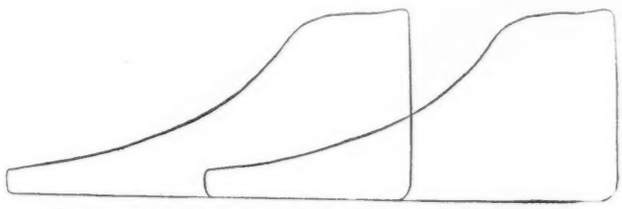


FIG. 3. DIAGRAMS TAKEN FROM A CONTINUOUS INDICATOR

within the cylinder occurring during each stroke to be studied and the horsepower developed by the engine per stroke measured.

Hopkinson Optical Indicator

To permit securing diagrams from engines operating at high speed, various optical indicators have been designed. The Hopkinson indicator, Fig. 4, has been more largely used than any other of this class. A

barrel *A* contains a piston *F* which is held by a shackle *G* to the flat spring *D*. The spring is supported upon two arms by the screws *E*. A mirror *H* is pivoted to the shaft *I*, which is connected by the arm *M* and the stirrup *L* to the spring. A slight deflection of the spring causes the mirror to rotate a slight amount on its axis. If a ray of light is allowed to strike the mirror, the partial rotation of the mirror will cause the image of the light to move in phase with the indicator piston, but the ratio of travel is large. The mirror and spring are mounted on a collar *B* which is rotated by the indicator cord. The two motions of the mirror cause the image of light to trace on a plane surface a diagram representing the pressure-volume conditions within the engine cylinder. If a sensitive plate is used, a photographic diagram results.

A recent optical indicator designed for gas engine work, but equally suitable for steam-engine testing, is the Midgley, illustrated in Fig. 5. In this instrument the indicator proper is fitted with a piston and a special spring. The piston rod is linked to a mirror at its top. Light rays from an electric bulb are thrown upon this mirror, which is shifted on a horizontal axis by the movement of the indicator piston. The rays are then reflected back upon an eight-sided mirror and thence upon the ground-glass screen, rising and falling with the change in pressure. The mirror is driven from the

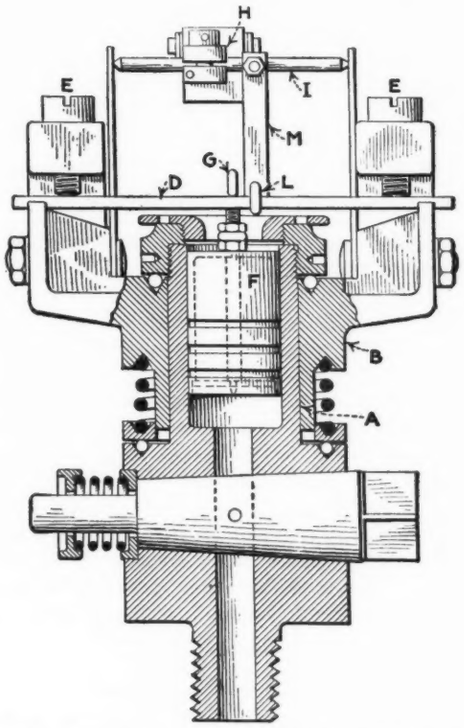


FIG. 4. HOPKINSON OPTICAL INDICATOR

engine in phase with the engine piston. This gives a horizontal movement to the ray of light. A diagram showing the cylinder events is then made on a sensitive plate or is observed by the reflection on the ground glass.

Comparisons of Optical and Standard Indicators

While early indicators often gave distorted diagrams, present-day instruments are apparently as accurate for speeds up to 600 r.p.m. as are optical indicators. A number of years ago several tests, as reported in *Engineering*, were made on the Hopkinson and piston indicators. These tests apparently proved that the optical device was no more accurate than the standard instrument. Beyond a speed of 600 r.p.m. the inertia of the indicator parts is such that the diagram secured is by no means accurate, and little dependence should be

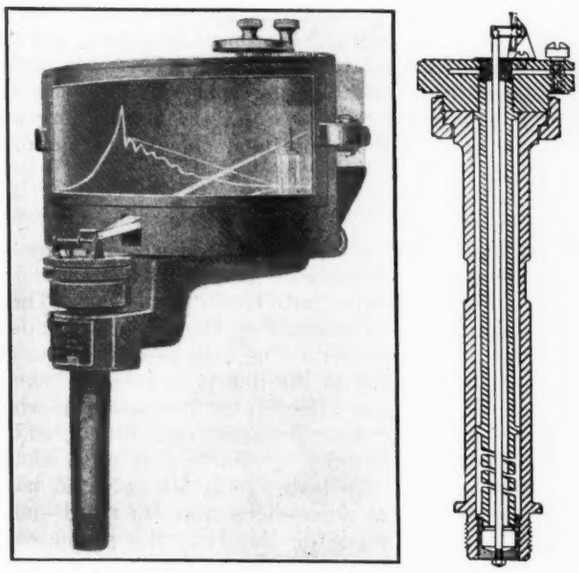


FIG. 5. MIDGLEY HIGH OPTICAL INDICATOR

placed upon the diagram from a piston-type indicator. On the other hand, the optical instrument gives fairly reliable diagrams up to 1000 r.p.m.

Loading Back with an Induction Motor

By H. M. Phillips
Electrical Aid, Public Works Department, Navy Yard, Washington, D. C.

In testing engines or motors it is common practice to obtain the desired load by connecting them to direct current generators. In some instances the generator load is obtained by the use of a rheostat, a water rheostat being quite frequently used if a considerable amount of power is involved in which case the energy developed by the generator is wasted. In order to utilize this energy the generator is sometimes connected so as to "load back into the line." If a direct-current motor of the same voltage as the generator is being tested, the generator can supply nearly all of the current required for the motor; only sufficient power to supply the losses in the two machines being taken from the supply line. This sometimes permits a test to be conducted when the available power is less than the rated capacity of the motor. In other cases the generator can pump current into the general distribution system and relieve the power plant of a portion of its load. In either case the load is readily adjustable by means of the field rheostat of the generator.

Loading by means of a squirrel-cage induction motor, driven above synchronous speed and arranged to pump back into the line, is also possible, but is seldom employed, principally on account of the difficulty of con-

trolling and adjusting the load. It can, however, be used where a direct-current line is not available, and permits the testing of induction motors with capacities higher than can be supplied by available alternating-current lines; and possesses some advantages in simplicity of operation. In working with a direct-current generator one must observe the same precautions in throwing it on to the line as are taken in throwing any two generators in parallel. If temporary connections are made for this work there is an increased liability of accident. As a matter of fact experience has shown that it may be cheaper in the long run to waste the power in a rheostat than to suffer the loss of time and occasional damage to apparatus incidental to pumping back on the line.

Precautions To Be Observed

Even when loading by using a rheostat there is danger of heavy overloads or short-circuits unless the apparatus is manipulated with considerable care. These troubles are largely eliminated by the use of the induction motor as a generator. The only precaution necessary in throwing it on to the line is to be sure that it is running in the same direction as it would run when operating as a motor with the same connections, which can readily be determined by starting it as a motor before commencing the test. It is advisable to have the motor running at somewhere near its rated speed before it is thrown on the line, but the permissible variation is so large that the use of a speed counter or tachometer is unnecessary. In fact if the motor does not exceed 10-hp. capacity it may be thrown directly on the line while stationary without ill effect other than the possible blowing of fuses.

On the other hand the direct-current generator may be adjusted to the desired load over a considerable range of speed, while the induction motor, of the squirrel-cage type, can give the desired load at one speed only, a very slight change of speed producing a large change of load. Any change in the frequency of the current in the line will also produce a considerable change in load, but under ordinary conditions little trouble arises from this source. Greater flexibility can be obtained by the use of a wound-rotor motor, the advantage of which is largely offset by the additional complication introduced in obtaining a suitable rheostat for the rotor circuit; that which is ordinarily furnished with the motor having too few steps to be of much service.

Load Adjustment on Induction Generator

In a few cases it may be permissible to obtain the desired load by varying the speed of the driver; using a field resistance on a shunt motor or adjusting the governor or throttle of a steam-driven unit. These cases are comparatively rare, and they give no opportunity to test the speed regulation of a motor or the governor action of a steam-driven unit.

At first thought it might not seem possible, but satisfactory adjustments of load may be obtained by varying the tension of the driving belt. It must be remembered that the "slip" of an induction motor of medium capacity and ordinary design is generally somewhere in the vicinity of 3 per cent, that is the full-load speed is about 3 per cent below the no-load speed. Conversely, when the motor is driven about 3 per cent above synchronous speed it will be operating as an induction generator loaded to its full capacity.

The slip of a belt under normal operating conditions may be assumed to be between 2 and 3 per cent. With a tight belt of ample capacity the slip may be reduced to 1 per cent or less, while a slack belt with light load may have as much as 10 per cent slip without running off the pulleys, burning or showing marked irregularity of action. If the driving and driven pulley are correctly proportioned the variation in slip from 1 to 10 per cent will be amply sufficient to give the desired adjustment of load and can be readily adjusted to the desired tension by the slide-rail adjustment with which most motors are furnished. With a flanged pulley on the generator and a tightener pulley designed for easy adjustment it is probable that a considerably greater margin could be obtained, which might provide for exceptional cases or allow greater latitude in regard to the sizes of pulleys used for the drive.

Connecting Motor To Operate as Generator

As a typical example of the utility of the induction motor to obtain a test load, assume that a 15-hp. 60-cycle 3-phase machine rated at 1,160 r.p.m. is to be tested and that a duplicate motor is available for loading. The synchronous speed of these motors is 1,200 r.p.m. and to obtain full load as a generator it will be necessary to drive at 1,240 r.p.m. At 50 per cent over-load the speed of the motor should be approximately 1,140 and the generator 1,250 r.p.m. These motors should be belted together with a 14-in. pulley on one and a 16-in. on the other. No starter is needed for the motor with the 14-in. pulley provided that there is no doubt of its being so connected as to run in the same direction as the other. If there is chance of their being incorrectly connected, the one should be started and shut down as soon as the direction of rotation is noted, and then the other can be started and if the rotation is correct the first motor immediately started also. If the motor is to run at 50 per cent overload, its speed should be about 1,140 r.p.m. which, without allowance for belt slip, would drive the generator at 1,303 r.p.m.; this allows a slip of slightly more than 3 per cent for the belt. If it is desired to run at half load, the speed of the motor may be assumed to be 1,180 r.p.m. which without belt slip would give a generator speed of 1,349 r.p.m. As only 1,220 r.p.m. are required, the belt tension would have to be adjusted for a slip of a little less than 10 per cent, and one-fourth load could be obtained with a slip of 11 per cent. As the actual full-load speed of the motor is likely to vary considerably from the name-plate rating, it is useless to attempt an estimate of the load from the speed; a wattmeter in the motor circuit should be used to measure the load.

The Mar. 24, 1922, issue of *The Engineer* (London) describes a recently completed experimental locomotive with steam turbine-electric drive. The turbo-generator takes steam at 200 lb. gage and 300 deg. superheat and exhausts to a 27½-in. vacuum. At 3,600 r.p.m., the capacity is 890 kw. and the voltage 600. The current produced goes to the driving motors. What corresponds to the tender in an ordinary locomotive contains the coal bunker and cooling-water tanks, as well as the condenser and its auxiliaries. The condenser is of the evaporator type and is supplied with air by a fan at the rear of the engine. A flexible pipe between the two portions of the engine connects the turbine exhaust to the condenser.

EDITORIALS

Power-Plant Performance Data

BRITISH engineering journals have recently published some interesting figures on the performance of certain of their power plants during the last year. The figures are not complete, yet they are of considerable value in making comparisons. Before the war very complete figures were published from time to time on the larger European power stations, and these served as standards to measure plant performance.

Engineers must regret that some means cannot be devised whereby such data covering American power plants could be published annually. Such comparisons would indicate which of the various styles of power plants now in service are giving the best results. Besides it would prove a tremendous incentive to the operating crews of power stations to improve performances by effecting still greater economies.

However, power-plant executives in general have been unwilling to release such data for publication. They maintain that such publicity would prove harmful to them and would not be in the public interest. This contention is based on the fact that public utilities in many instances have been the target of the politician and the agitator. Few people have the slightest idea of what elements enter into the determination of a just and equitable rate for light or for power service. They do not comprehend that a rate of ten cents a kilowatt-hour to a domestic user who consumes only relatively few kilowatt-hours a month may be as fair, just and reasonable as a rate of two cents a kilowatt-hour to a large power user who takes service largely during off-peak hours. Maximum demand, load factor, diversity factor, distribution losses and stand-by reserve mean little or nothing to the average man on the street. Yet these all exert tremendous influence on the cost of delivered power. Under such circumstances it is only natural that utilities fear to divulge the true performance figures although in most cases the danger is more fancied than real.

But why should the engineering profession be made the loser because of a condition that can be overcome, or at least is worth the effort? There is a real need of a popular educational campaign concerning the basis of rate making. If more people really understood the elementary considerations entering into the formation of rates for different services, unwarranted attacks against utilities would be less frequent and bona fide appeals for readjustment of rates would not be contested so bitterly. Some way may yet be found to present the essential facts without inviting trouble. The group of papers on heat balance recently presented to the American Society of Mechanical Engineers created widespread interest, as actual plant data were presented, and the paper on performance at Colfax, to be read at the spring meeting of that society in Atlanta, will be another step in the same direction. Let us hope that ultimately engineers will be able to learn what our American power plants are actually doing.

Air Heaters a Live Topic

"THERE is nothing new under the sun," runs the old saying. That this is true in the case of the air heater is proved by the voluminous records of the experiments that J. C. Hoadley made at Lawrence, Mass., in 1882. As reported before the American Society of Mechanical Engineers in 1884, it appears that surprisingly good results were obtained in these tests, yet there resulted no general application of devices to preheat furnace air by means of the flue gases. The fact is that, except for a few sporadic experiments and occasional wonderings, the subject (at least in America) seems to have been as dead as the proverbial door nail. The reason for this lay largely in the fact that the low cost of fuel gave little incentive to economy.

Of late there has been a reawakening of interest in the subject. This has been evidenced by the interesting discussion that grew out of the article by E. R. Welles and C. T. Mitchell in the Nov. 29, 1921, issue of *Power*.

Present discussion of the subject in this country seems to be on a more-or-less theoretical basis for the simple reason that few facts are at hand. Meanwhile Europe, where the issue has been forced by the high price of fuel, has put many preheaters into daily operation. In view of this unusual condition *Power* believes that a discussion of European apparatus and practice will be helpful. As a starter it presents in this issue a description of one European preheater that is in common use on the other side of the Atlantic.

It is not the purpose of the present discussion to recommend for American conditions the use of this or any other type of preheater, but only to shed a little light on the subject. Readers who have given constructive thought to the matter or who know the results of unpublished experiments along this line, can help their fellow engineers by sending in their views or findings.

Trend in Ammonia Compressor Design

UNTIL a few years ago the ammonia compressor was a slow-speed machine with a small capacity per ton of metal. Since the majority of these machines were direct-connected to Corliss engines, there was little inducement toward the speeding up of the units. The development of the raw-water ice system made a large supply of exhaust steam no longer necessary and other drives came into existence. The synchronous motor and the modern unaflow steam engine operate at speeds much above that of the Corliss engine, and to employ these prime movers entailed a radical change in compressor design, for the speeding up of compressors equipped with heavy poppet valves was limited by the failure of the valve to function at any but low or, at the best, medium revolutions per minute. The adoption of the high plate valve has removed these limitations, and at present compressor speeds are double or treble that of ten years ago.

As pointed out in a discussion of ammonia-compressor valves on another page, it is possible by replacement of the poppet valves by light plate valves to increase enormously the tonnage of present installations. It would seem that this should be of distinct advantage to the refrigerating plant. If the compressor capacity can be increased, then by the addition of a greater condenser and evaporating surface the plant output is increased at a minimum expense. There is a drawback in the probable shorter life of the higher-speed machine, for it is generally conceded that the life of a machine is somewhat in proportion to the total revolutions and not in proportion to the total piston travel.

Results at Lakeside

PULVERIZED coal for power generation may be assumed to have passed the experimental stage and to have taken its place beside the stoker and fuel oil. A number of such plants are in successful operation, but are mostly installations that have been converted in part or in whole to meet changed conditions. Particular interest, therefore, centers about the Lakeside Station in Milwaukee, not only because it was designed expressly to burn pulverized coal, but also because to date it is the largest central station of this type. It has been in continuous operation since December 15, 1920, and outside of certain minor difficulties such as might be expected in a new venture, satisfactory results are reported.

Official tests conducted on individual boilers have shown remarkable results, and all who have visited the station have been impressed with the flexibility in boiler operation. Nevertheless, what engineers want to know especially is something about the every-day performance, operating costs, maintenance, how the slag problem has been met, etc. Thus far, however, the management has preferred to talk generalities only and has refused to take the engineering profession behind the scenes in this pioneer installation. Therefore, those who have been awaiting these results with a view to possible adoption of powdered fuel to their own problems, must necessarily feel keen disappointment, for it is obvious that avoidance of a frank discussion of the results does not tend to stimulate use of powdered fuel.

Why Not Use a Slide Rule?

TEN years ago the average practical man turned up his nose at the "guess stick," as it was derisively called. This was mainly due to the following causes: Natural suspicion of anything unfamiliar; the frequent association (particularly in the case of young technical graduates) of slide-rule skill with ignorance along practical lines; bad blunders made by careless users of slide rules; the "inaccuracy" of the slide rule. Since that time the number of practical men who make daily use of the slide rule has greatly increased, but some of the old prejudice still lingers.

The chief remaining objection to the use of the slide rule is that it is "not accurate." This is true in precisely the same way that an ordinary six-foot rule is not accurate. When a distance measured with such a rule is read as 5 ft., 4¾ in., the exact distance might very well differ from this by ⅛ in. without reflection on the maker of the rule or on its user. For most purposes this degree of accuracy is entirely sufficient, yet no mechanic would try to use a six-foot rule in turning a pin to the proper diameter for a drive fit. He would use a micrometer instead. It all comes down to the old admonition, "Know your tools."

When using the long scale of a ten-inch slide rule for multiplication or division, the thing to remember is that one cannot expect to read closer than about one part in a thousand. If the exact answer is 1,012.2, a competent operator may read 1,011, 1,012 or 1,013. He will not ordinarily go beyond these limits. If the exact answer is 0.4016, the slide-rule answer should come between 0.4010 and 0.4020. For each problem that arises, only a certain degree of accuracy is required, and it takes but a moment to see whether this lies within slide-rule limits. Ninety per cent of the time it does. In fact the original measurements in most power-plant problems are out by more than one part in a thousand. In such cases the apparent absolute exactness of "long-hand" arithmetic is nothing but an illusion.

The power-plant engineer who is skilled in the use of the slide rule and thoroughly acquainted with its limitations, can save a lot of time without sacrificing any necessary accuracy.

The Gas Turbine

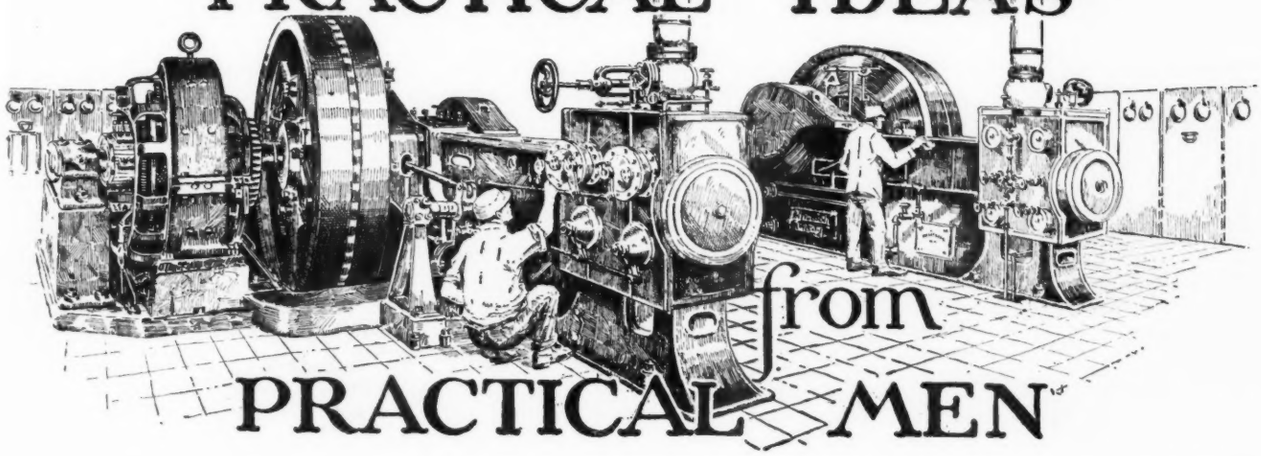
OUTSIDE of German engine builders apparently no engineering manufacturer has recognized the possibilities of the oil-gas turbine. While the cost of development work is high, still the organization that places a commercial gas turbine upon the market should find the returns ample to justify the outlay.

The oil-gas unit has shown an over-all thermal efficiency of 28 per cent. This represents a marked increase over the best steam-plant results. In addition, the labor charge should be largely reduced by the elimination of the boiler room. True, the gas turbine has been built only in comparatively small experimental units, but the experimental work has gone far toward eliminating the blade trouble that existed in the first machines.

At the present time a ten-thousand-kilowatt unit arranged to burn oil is being built in Germany. This machine is a decided advance over the first units, and there is every reason to expect that it will prove reliable. The blade temperatures, which have been the stumbling block, are kept within reasonable bounds by making the process of combustion intermittent instead of continuous. This reduces by about one-half the blade and wheel temperature. If this ten-thousand-kilowatt machine proves successful, engineers may confidently look forward to the time when at least some of the larger stations as well as small plants will be equipped with gas turbines.

A man who recently stopped off at a village in western Massachusetts found a good-natured young fellow in charge of the local one-hundred-kilowatt "hydroelectric station." This "engineer" willingly answered all kinds of questions with the confident air of the man who knows what he is talking about. The visitor—who was not a technical man—ventured to ask whether the generator voltage of twelve hundred was sufficient to kill a man. In reply came the illuminating information that neither this nor any other voltage could hurt anybody as long as the load on the generator was small. Moreover, he was quite sure of it. We wish him the best of luck.

PRACTICAL IDEAS from PRACTICAL MEN



Testing Series Field Coils

Upon taking charge of a plant, it was discovered that one of the direct-current generators sparked considerably as the load increased, and no amount of brush shifting would relieve the trouble. The machine was compound wound, had 10 poles and generated 240 volts. This machine also had a tendency to shirk the load when operating in parallel with the other machines.

After carefully adjusting and setting the brushes without remedying the trouble, it was decided to test the shunt-field coils for short-circuits and for polarity. To do this, the armature and equalizer connection was disconnected at the machine, as shown at *X* on machine *A*, Fig. 1. Then the switch was closed to the busbars. This connected the field coils of machine *A* directly to machine *B* as indicated by the arrowheads. The polarity of the field coils was then tested with a compass and found to be correct—alternate *N* and *S* poles. To test for short-circuited coils, voltmeter readings were taken from the terminals of each shunt-field coil, as indicated at *C*. On a 10-pole 240-volt machine with a voltmeter connected to the terminals of one of the

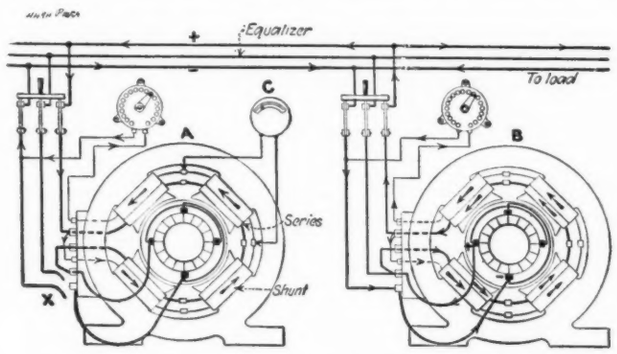


FIG. 1. CONNECTIONS FOR TESTING SHUNT-FIELD COILS OF DIRECT-CURRENT GENERATORS

shunt-field coils, as in the figure, a reading of 240 ÷ 10 volts should be obtained, which proved to be about the conditions found. Therefore, it was decided to look elsewhere for the trouble.

The next thought was to the series winding, as it was felt that some of these coils might have wrong polarity. To test the polarity of these coils offered a problem somewhat different from that of the shunt coils. The shunt winding could be connected directly across the line, but the series winding, having a low resistance, would have to be connected in series with a resistance, if connected across the busbars. Furthermore, since the coils had only 2½ turns, a fairly heavy current would be required to magnetize the pole-pieces. Of course this could have been done by connecting a water rheostat made from a barrel, in series with the coils, but this would involve no small amount of work, besides placing considerable load on the machine in operation.

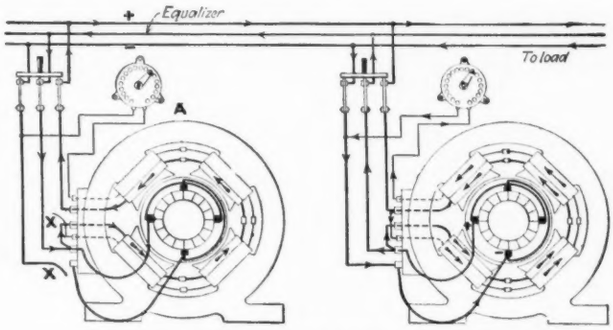


FIG. 2. CONNECTIONS FOR TESTING SERIES-FIELD COILS OF DIRECT-CURRENT GENERATORS

Both these factors made us look around for an easier method of doing the job, and as a result we fell upon the idea of connecting the series winding of this machine in parallel with the other machines. The connections for doing this are shown on machine *A*, in Fig. 2. The shunt-field circuit was opened at the machine and the armature wire disconnected as shown at *X*. This left only the series winding connected to the switch, so that when the switch was closed, as in the figure, this winding was connected to the equalizer and positive busbars, the same as the series winding of the other machine, and put these windings in parallel. With the connections, Fig. 2, part of the current that originally flowed through the series winding of machine *B* now flows over the equalizer connection and through the series winding of machine *A* and to the load. To compensate for the drop in voltage of machine *B* caused by being robbed of part of the load current, its voltage was made about 5 volts high before closing the switch on *A*. A period was chosen for making the test when

the other machine was carrying considerable load so as to have sufficient current through the series windings of *A* to establish the polarity of these coils. On testing these coils with a compass, it was found that three adjacent coils had the same polarity. The middle pole-piece was removed and the series coils reversed and put back into place. When the machine was put into service again, the sparking at the brushes had practically disappeared, and no further trouble has been experienced. CHARLES A. ARMSTRONG.

Boston, Mass.

Insulating Armature-Coil Leads

The so called sleeves which are slipped on to armature coil leads to insulate them from each other where they lie close together between the core and commutator, must be installed by hand. Where small wires are involved, it is sometimes difficult to get the sleeving on because the sharp end of the wire tends to stick into the side of the sleeve, the hole of which is not well defined in the flattened material. In some cases the job is simplified by doubling the end of the wire back before pushing it through the sleeve.

THIMBLE TO GO ON END OF WIRE

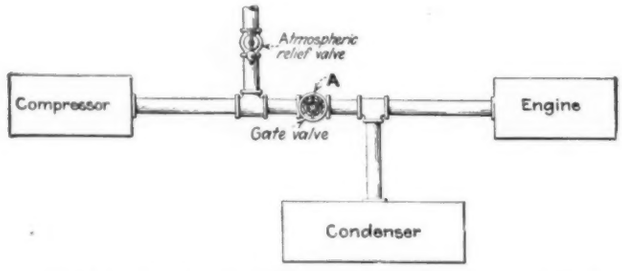
The diagram shows a little thimble which may be made of fiber or metal and is slipped onto the end of the wire. The thimble and wire may then be pushed through the sleeving easily. E. C. PARHAM.

Brooklyn, N. Y.

Why Does the Vacuum Drop?

A peculiar problem confronted us in the operation of a cross-compound pumping engine and a compound air compressor exhausting into one condenser. The general arrangement is shown in the illustration. The suction water to the pump is passed through the circulating-water section of the condenser, and the air pump is driven from the mainshaft of the engine.

The pumping engine was started first, exhausting to the atmosphere, and after the pump was delivering sufficient water, we would close the gate valve *A* and the vacuum would rise to 27 in. The air compressor was



GENERAL ARRANGEMENT OF UNITS AND CONDENSER

then started exhausting to the atmosphere, and as soon as steam would blow through the relief valve in the exhaust line, the vacuum in the condenser would fall to 5 in. with the valve *A* closed. When valve *A* was again opened and the relief valve closed, the vacuum would rise to 27 in.

Since this always happened in starting up, we now start the engine and compressor exhausting to atmosphere then by closing the relief valve change both to condensing at one time.

Can some engineer explain what caused the vacuum to drop with the compressor exhausting to atmosphere and the pumping engine operating condensing with the gate valve *A* closed? E. B. SNYDER.

Bellefontaine, Ohio.

Flexible Exciter Switchboard

In Fig. 1 is shown the main connections of an exciter switchboard that was installed some years ago to control three belt-driven exciters. These exciters were driven by extensions of the alternators' shaft, and the diagram shows that all three fields can be fed from No. 1 exciter when the switch on No. 1 alternator is in the down position and those on Nos. 2 and 3 alternators are in the up position. There is a transfer system of the alternator fields between No. 1 and No. 2 exciters, while No. 3 alternator field can be supplied only by its own and No. 1 exciter. Normally, each field is on its own exciter by throwing all switches down, but in an emergency excitation could be obtained by throwing the respective field switches as indicated in the foregoing.

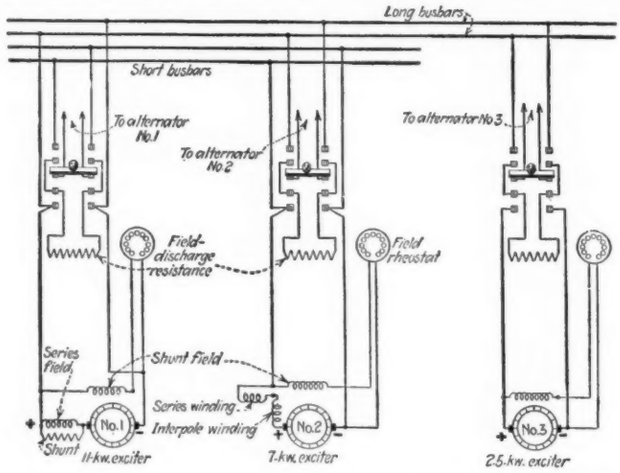


FIG. 1. ORIGINAL CONNECTIONS FOR THREE EXCITERS

This outfit proved satisfactory and remained in service throughout several changes in the alternating-current equipment. Later, alternators Nos. 2 and 3 were replaced with modern turbine-driven machines with direct-connected exciters with compound windings and interpoles, while No. 1 outfit was retained. It was decided to remodel the exciter switchboard and install a Tirrill regulator and to operate the exciters in parallel when more than one was running and have all controlled by one regulator. Fig. 2 shows the changes made, which consisted of the installation of triple-pole switches, ammeters, fuses, equalizer, direct-current voltmeter, voltmeter receptacles and bus, main buses (which were improvised from the old ones), equalizing rheostats (needed on two machines only), a Tirrill regulator and the necessary circuits.

Ordinarily, each alternator's field is fed by its own exciter, by throwing the double-pole switches down, but they can be supplied from the busbars by throwing the double-pole switches up, since the buses are always alive in order to provide potential for the direct-current part of the Tirrill regulator. Each outfit consists of an exciter and an alternator's field as a unit, and when the

triple-pole switches are in, all units operating at the time are in parallel through the busbars, which normally carry no current except that for the regulator coils. The triple-pole switches of all idle exciters are out and those of the active exciters in, thus keeping the busbars alive at all times so long as one or more machines are running.

When the exciters are in parallel and the load tends to divide unequally between them, it is easy to change this condition by means of the equalizing rheostats connected to those exciters that tend to take more than their share of the load.

On account of considerable difference in the resistance of the series field of the new No. 3 exciter as compared with the resistances of the other series fields, it was found necessary to insert resistance in No. 3 series coil in order to prevent this machine from taking all the load.

I have noticed that on account of the differences in the exciters and alternators' fields the regulator

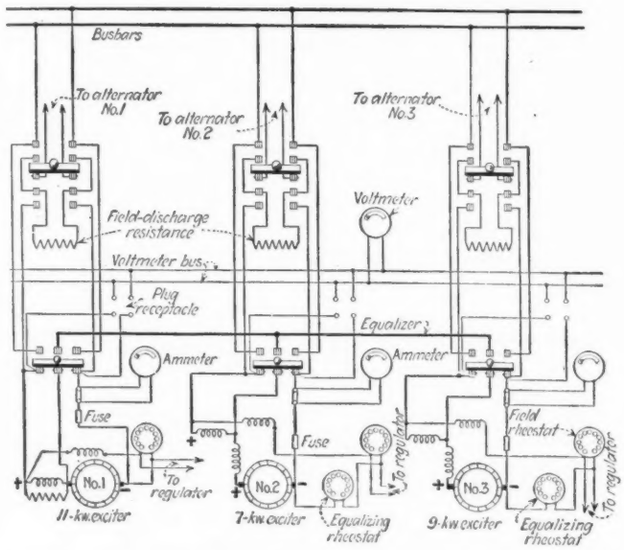


FIG. 2. CONNECTIONS FOR THREE EXCITERS AFTER CHANGES WERE MADE

has different vibration rates when connected to the machines singly, but these rates are averaged when connected to any number of machines jointly, and division of load on the exciters is taken care of in these instances by the equalizing rheostats. HENRY MULFORD.

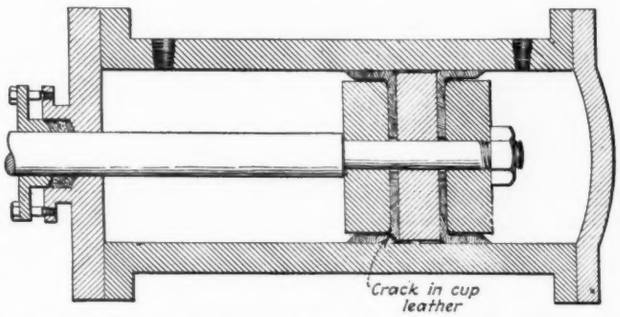
Patchogue, N. Y.

Bran Stops Leak in Piston Packing

During a construction repair job on a concrete conduit it was necessary to close a 30-ton gate at the entrance end of the conduit. This gate was a 13 x 13 ft. steel frame filled with concrete and operated by a hydraulic cylinder at 250 lb. pressure. The gate had been previously opened and shut without difficulty. However, it was again closed and the water drawn off the conduit in order to proceed with the repairing of the concrete corewall.

At the completion of the work it was found impossible to open the gate or to keep sufficient pressure on the cylinder to lift it. Valves in the pump and also the relief valves were examined, but no evidence of the trouble could be found. Meanwhile a 15,000-kw. plant had to be shut down.

It was finally concluded that the cup leather packing on the piston had sprung a leak, and as no hoisting material could be obtained to use under water, it was



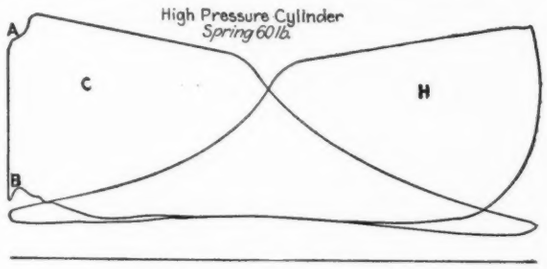
MIXING BRAN WITH THE OIL TEMPORARILY STOPPED THE LEAK IN THE CUP LEATHER

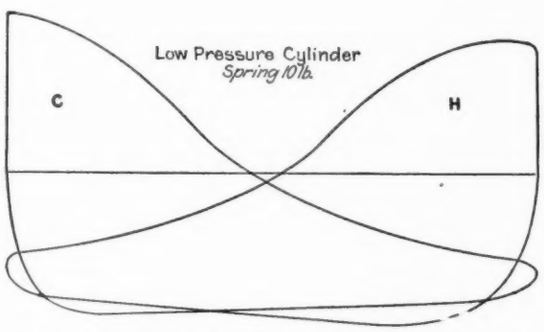
decided to mix bran with the oil, using 100 lb. of bran to about 3 bbl. of oil. This was done, and the gate was finally opened and latched into place.

Shelburne Fall, Mass. H. B. SOPER.

Indicator Diagram for Criticism

I should like to have some *Power* reader to criticize the two indicator diagrams shown. I should like to know what causes the curve *A* and the drop in pressure



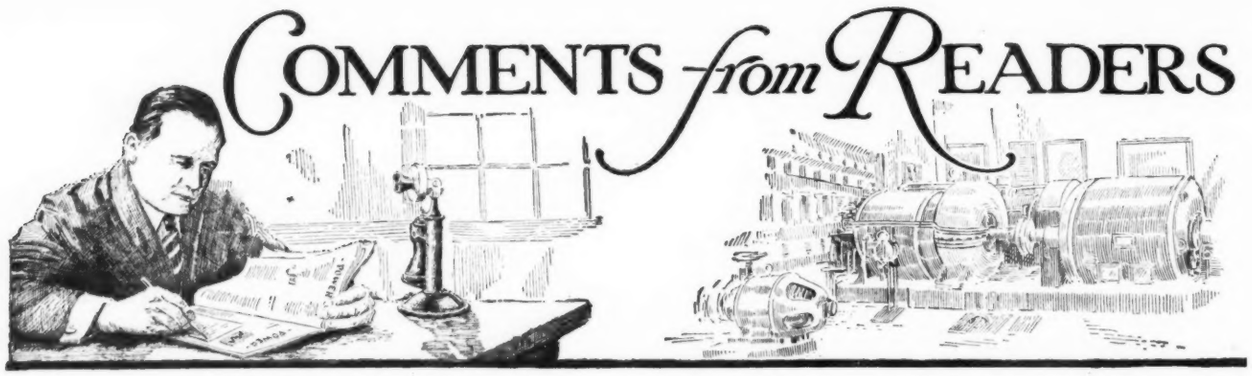


DIAGRAMS FROM COMPOUND CORLISS ENGINE

at *B*. I am at a loss to understand why the back-pressure line on the low-pressure diagram has the slope shown.

These diagrams are from a 14 x 28 x 36 Corliss and the peculiarities are reproduced in every diagram taken from this engine. JOHN R. SPUGG.

St. Louis, Mo.



Chattering of Brushes

I noted with interest the letter by Mr. Anderson in the Feb. 21 issue on eliminating the chattering of brushes. From observation and opinion my explanation as to what takes place is as follows: First, the boring of this hole naturally reduces the amount of brush surface that has to be held firmly to the commutator. This surface being lessened, it allows the tension to put more pressure on the brush, causing it to hug the commutator more firmly. But from a practical view point this does not assist the brush as much as would be imagined. Secondly, provided the brush is well fitted to the commutator over its full surface, the segments of the commutator passing this hole at high velocity have a tendency to fan all the air out of the hole in the brush (especially if the mica is undercut); this produces a vacuum, thereby causing the brush to be pulled tighter to the commutator and retained there more continuously than if it did not have a hole in it.

Victoria, Tex. H. W. ROSE.

Water in Steam-Engine Cylinder

Referring to the article by F. C. Eaton in the Jan. 31 issue on the question of water flowing back to the engine cylinder when operating with a barometric condenser, let us first consider the conditions under which this might take place.

With an atmospheric pressure of 14.7 lb. a 30-in. vacuum will support a column of water 34 ft. high. Usually barometric condensers are placed more than this minimum number of feet above the level of the water in the hotwell to safeguard against the water in the tail-pipe rising high enough to overflow into the exhaust pipe; so, in order to get water back into the exhaust pipe there must be either an increase of the pressure outside or a decrease in the weight of the water in the tail-pipe. The former is out of the question, but if more air is admitted with the water in the tail-pipe, it will decrease the weight of this column an amount equal to the water displaced by the air, and therefore the height of this column will be increased proportionately. If this increase in level is greater than the distance between the normal level and the exhaust inlet, water will overflow into it.

If the air admitted with the water into the tail-pipe is through a hole 6 ft. above the surface of the hotwell, it will affect the volume of water between that point and the outlet of the tail-pipe. The downward movement of the water will counteract the tendency of the air to rise to the condenser, and the decrease in weight of water per unit of volume will be between the hole and the tail-pipe discharge. Now, if the same size hole is drilled 20 ft. above the surface of the hotwell, the volume of water affected by the mixture of air is more than three times that in the former case. Then the weight of the water in the tail-pipe is decreased more than three times as much as before. Assuming the same amount of air has been admitted in each case and the same vacuum maintained in the condenser, the height of the water in the tail-pipe will have increased proportionately with the increase in height of the hole above the surface of the hot-well, and this may be sufficient to cause the water to overflow into the exhaust. GEORGE B. LONGSTREET.

Somerville, Mass.

Operating Troubles with Duplex Pumps

With reference to the letter on operating troubles with duplex pumps in the March 28 issue, in my opinion air pockets carried over with the yeast are the principal cause of the trouble, but increasing the size of the box from which the yeast is taken would not remedy this. It is possible that the yeast has formed a lining on the inside of the pipes, thereby restricting the flow to the pumps, or the suction pipe may be too small. In the latter case increasing this to 3 in. might eliminate the trouble.

Another way to improve the operation of the pump is to install an air chamber on each suction pipe close to the pump and on the top of each air chamber connect a ½-in. swing check valve to open outward. This will relieve the air and also prevent air from being drawn in if the suction supply gets low. These air chambers will also act as a storage and will give better results than increasing the size of the yeast box. They should be placed so that the yeast will flow freely to them.

New York City. P. J. MOLLOY.

Mr. Brown does not say whether the yeast flows to the pumps under a head or whether they have a suction lift. In the opinion of the writer the trouble may be caused by either one of two things: First, the pumps may not have sufficient valve area for the yeast to pass through fast enough to keep the pump chambers full, thus making the pumps short-stroke the same as they will do if not getting enough water; or, if the pumps are operating with suction lift, there is a possibility that the pistons are not tight enough to create sufficient suction to lift the yeast and fill the cylinders. This trouble might be corrected by giving the steam valves enough lost motion to delay the operation of the pistons long enough to let the pump chambers fill with yeast.

Hudson, N. Y. D. G. SIMMONS.

Steel of Low Tensile Strength Used in Air Tanks

In the article on the "Disastrous Air-Tank Explosion" in the March 21 issue, 55,000 is assumed as the tensile strength of the plate. As a matter of fact the usual air tank has no such grade of steel. The writer has recently investigated the quality of steel used in air-compressor tanks and finds that the manufacturers in many cases are using the sheared ends of the open-hearth steel plate which averages 38,000 to 42,000 lb. tensile strength. Out of twenty firms making tanks, only five were using 55,000- to 65,000-lb. tensile-strength plate. The others were using steel around 40,000 lb. Actual test sections of tanks that are not bought on steel specifications but supplied with the equipment showed a poor grade of steel.

From a standpoint of safety all air tanks should be figured on a safety factor of 5 with steel of 55,000 tensile strength. All joints should be double-riveted in small sections; for $\frac{3}{8}$-in. sections and heavier plate, the riveting should be such as to insure at least 70 per cent joint efficiency. On many tanks now in use the efficiency of the joint is around 48 to 60 per cent. Single riveting should not be used on pressure tanks of 100 lb. pressure or higher.

The reason for the failure of many tanks is the light construction allowing an alternating bending around the rivets with the air impulses from the compressor. This rapid alternating bending soon causes fatigue.

Chicago, Ill. H. E. WEIGHTMAN.

Method of Tagging Valves

In the article, "Safety in Tagging Valves," in the Feb. 21 issue, a plan is outlined for a system of tagging, calling for a pipe-line dispatcher, whose office would be similar to that of the load dispatcher on the electrical system. While the idea has its good features, the appointment of a dispatcher is, in my opinion, unnecessary, as the watch engineer should know the condition of every valve and pipe line in the power plant.

In an electrical system tying together several generating stations and serving a large number of sub-

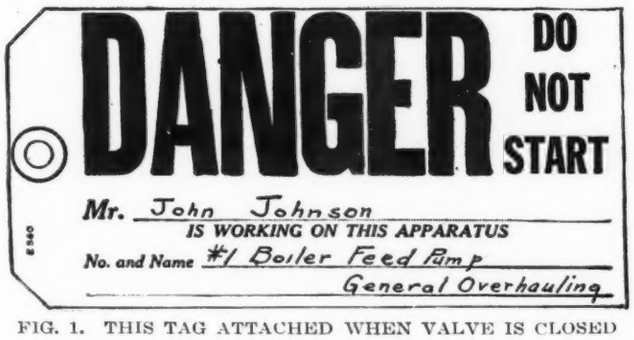


FIG. 1. THIS TAG ATTACHED WHEN VALVE IS CLOSED

stations, a load dispatcher is necessary to control and direct the movements of the individual switchboard operators, in order to assure safe and continuous service. On the steam end, however, all the piping should be under the control of one man, the watch engineer, and a dispatcher, if appointed, would have to receive his orders from him, as it would be difficult and dangerous to operate a plant where the engineer did not know what changes took place.

Numbering valves is the clearest possible way of designating them, as calling a valve by number would indicate exactly which one was meant. For simplicity the numbers can be omitted, as a valve can be readily indicated by its function, location and the unit or pipe line it serves. If an order were given to close and tag the stop valve at the header on the steam line to No. 2

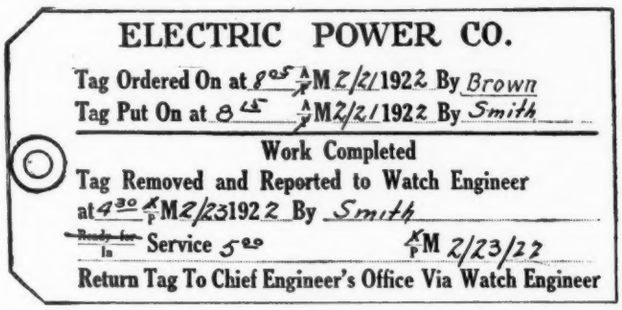

ELECTRIC POWER CO.
Tag Ordered On at 8 05 AM 2/2/1922 By Brown
Tag Put On at 8 45 AM 2/2/1922 By Smith
Work Completed
Tag Removed and Reported to Watch Engineer
at 4 30 PM 2/23/1922 By Smith
Ready for Service 5 00 PM 2/23/22
Return Tag To Chief Engineer's Office Via Watch Engineer

FIG. 2. SHOWS THE OTHER SIDE OF TAG FILLED IN WHEN WORK IS COMPLETED

turbine, it would be as clear as saying, "close and tag valve H.S. 24."

A method of tagging used by one power company in its generating stations is shown in the illustrations. This tag is white with red lettering and is readily seen when attached to any apparatus.

By way of explanation in the use of these tags suppose a turbine-driven feed pump was to be opened for overhauling. John Johnson, who was to have charge of the work, would go to Mr. Brown, the watch engineer, and request that the pump be turned over to him for such repairs. The engineer would order Smith, his assistant, to close all the valves, both steam and water, to No. 1 boiler-feed pump and tag them, for Mr. Johnson. Tags would be made out as shown in Fig. 1, and as each valve was closed a tag would be wired on the wheel. The unit would then be ready for overhauling.

When the work was completed, Johnson would report back to Brown, and all valves would be opened and the tags removed and the back of the tag filled in as shown in Fig. 2.

It will be noted that, by properly filling out the tags, a record is obtained showing by whose order and by whom the valve was opened or closed, the foreman in charge of the work, also the time of all these events and the reason and length of time the apparatus was out of service.

In general, whenever a valve that is normally open is closed, or one that is normally closed is opened, a tag must be placed on it, telling why its position was changed, as all apparatus and valves are in normal operating condition unless tagged, the accidental opening or closing of valves causing injury to workmen or interruption of service is prevented. ADOLPH QUADT.

Perth Amboy, N. J.

There are no means for obtaining, with a frequency-changer set, the exact 60 to 25 relation with an economical type of machine, for the numerical ratio of 60 to 25 allows only a 24- to 10-pole machine combination, which represents a rather low speed except for units of large capacity. If any other more economical combination of poles is chosen, such as 10 to 4 or 14 to 6, then, with a 60-cycle supply system, some other frequency than 25 cycles will be obtained.

QUESTIONS AND ANSWERS

Cleaning Injector Tubes

How can injector tubes be cleaned of mud and scale? W. N. A.

After removing the tubes from the body of the injector, they should be cleaned of grease by washing them in a strong solution of potash and hot water, and after a rinsing in clean hot water, the parts should be dipped in a solution of one part of muriatic acid to ten parts of water, but only enough to soften the deposits, when the tubes should be quickly washed to check the corrosive action of the acid. Remaining deposits that are not readily removed can be softened by local applications of the acid solution and removed with a scraper made of sheet brass, taking care after each application of the acid solution to wash the tubes clean to prevent unnecessary corrosion.

Resetting Slipped Eccentric

If the eccentric of an engine has slipped on the shaft and it is necessary to have the engine running as soon as possible without placing the crank on a dead center, how can the eccentric be reset? J. R. A.

First, turn the eccentric around on the shaft in the direction of rotation of the engine until the admission-valve opening is correct for the beginning of a stroke of the piston from that end of the cylinder from which a stroke has been partly completed. This position of the eccentric can be approximately determined by alternately setting the eccentric forward and opening the throttle valve only enough to observe whether steam escapes from an indicator connection or cylinder pet cock in the same end of the cylinder but without moving the piston. Then make a light mark on the shaft to correspond with a mark made on the side of the eccentric, and estimate the angle through which the crank would have to be turned backward to bring the crank on a dead center, and set the eccentric the same angle forward of the position previously determined.

Feeding Boiler with Tank Pump

If a tank pump is of sufficient size and strength for handling the quantity of feed water required by a boiler that is operated under 70 lb. pressure, can it be used in an emergency as a feed pump for the boiler, if the steam and water cylinders of the pump are of the same diameter, if the pump is supplied with steam from the same boiler and the suction water is supplied to the pump at a pressure of 50 lb. per sq.in.? With frictional resistances to be overcome, it seems peculiar that the pump could be started with a steam pressure of 70 lb. per sq.in. against the same boiler pressure and a pressure of 50 lb. on each side of the water piston? R. F. T.

For establishing a discharge of water to the boiler, the pressure per sq.in. on the discharge side of the water piston needs to be no more than the steam pressure required for overcoming the weight of the check valve, and pressure for overcoming the friction of flow through the feed pipe and pump passages. Ordinarily, the resistances in addition to the boiler steam pressure would amount to less than 10 lb. per sq.in., and to discharge against 70 lb. boiler pressure, the pressure required on the discharge side of the piston would be less than 80 lb. per sq.in. Under average conditions less than 10 lb. per sq.in. of steam pressure would be required for overcoming rubbing friction of the pump parts and back pressure of the exhaust, and when supplied with steam at 70 lb. boiler pressure, there would be a net steam pressure of 60 lb. per sq.in. acting in the same direction and on the same size of piston as the suction-water pressure of 50 lb. per sq.in. Hence together they could, if necessary, exert the equivalent of $60 + 50 = 110$ lb. per sq.in. acting on the suction side of the water piston, or $110 - 80 = 30$ lb. per sq.in. more than necessary for feeding the boiler.

Receiver for Reducing Pulsations in Pipe Line

We are troubled with the vibration of a steam line, caused by pulsations of steam which appear to be due to the sudden cut-off of the inlet valves of a triple-expansion engine with Corliss valve gear. The engine speed is about 90 r.p.m. with cut-off at about 0.6 of the stroke. The engine branch pipe is 7 in., taken out of a 10-in. header for supplying steam from boilers that carry 180 lb. gage pressure. Cannot the vibration be prevented by employing a receiver in the steam pipe close to the engine? C. G. A.

A receiver about four times the volume of the high-pressure cylinder of the engine will furnish a charge of steam to the engine for each period of admission with less sudden variations of the pipe-line pressure and, by throttling the inlet, the flow into the receiver and the line pressure can be made more nearly uniform without serious reduction of pressure of steam delivered to the engine, as the supply to the receiver will be made up by flow continued after cut-off. As a receiver acts to some extent like a separator, the steam outlet should be placed near the top and there should be ample provision for drainage of condensation out of the bottom of the vessel. Otherwise slugs of water might be carried over to the engine; and to reduce the formation of condensate from radiation of heat from the sides of the receiver, they should be covered with good insulating material.

Opposition to Patent Working Clause

Provision for compulsory working of patents within a specified time, which is the most important feature of the Stanley Bill, introduced in the Senate by Senator Stanley, was so strongly opposed at a recent meeting of the committee that is considering the subject that the Senator has decided to redraft the bill. As it stands, the measure provides that if the patentee does not manufacture the device covered by the patent in reasonable quantities within a reasonable time, the Government will have the right to issue a license for its manufacture by someone else. An additional provision is that a "reasonable time" shall be not less than two years nor more than five years after the patent is issued, and it is this part of the bill that Senator Stanley expects to change by leaving it to the Commissioner of Patents to set the "reasonable time."

Among those who have actively opposed the bill are A. C. Oliphant, representing the Federated American Engineering Societies, Frederick P. Fish, well-known patent attorney of Boston, and Thomas E. Robertson, Commissioner of Patents. Mr. Robertson declared himself unalterably opposed to a working clause, saying that the patentee must be given a monopoly to encourage invention and to make the patent readily salable. He held that a working clause would discriminate greatly against the poor inventor, who often obtains capital for manufacturing only after considerable delay. Another point brought out at the hearing before the committee was that patents are often taken out during the research period simply for protection until the device is perfected, and that any provision for compulsory production at such a time would be a severe blow to all research.

What the A.A.E. Says About Engineers' Commissions

Should an engineer accept a commission from manufacturers for material supplied for work that he is superintending? It is generally understood that he should not, but there are doubtless many, both among engineers and manufacturers, who either do not know of such a principle or else do not believe in it.

The attitude of one of the national engineering societies on this matter was recently presented with unusual clearness, in a decision of the practice committee of the American Association of Engineers. The case was summarized as follows:

A, a member of the American Association of Engineers, is a city engineer, supervising the construction of a power plant. B is a manufacturing corporation building devices used in power plants. B offers, in writing to A, "its regular 10 per cent engineer's commission on the total sale," and also advises, "Commissions to engineers are usually more or less confidential and we can assure you that the above will be kept strictly to ourselves." Upon A's refusal to accept the offer because he is paid a salary for his work, B advises that no offense was intended, but only a desire to express "its willingness" to show consideration. B claims that in 90 per cent of cases the commissions are expected and in several cases plans are completely changed by engineers for the reason that no offer for commission has been made. B says further: "In many cases such action is very justifiable, for present-day business ethics should provide more generously for the engineers, but in other instances the engineer is exceedingly well taken care of and should not expect a commission. In any event all engineers should decide only by the merit of the equipment and conscientiously make the selection in accordance with their best judgment."

Question: What is the duty of the American Association of Engineers in matters of this nature?

Answer: B is a public menace. If there are any engineers employed or connected with this company's management, they should be asked to repudiate the correspondence and correct this practice. Failing in this, if members of the American Association of Engineers, they should be expelled and reported to other engineering societies if members thereof. Also, the American Association of Engineers should publicly commend A for reporting this matter and also publicly condemn the practices mentioned, which, fortunately, are not very general as B seems to allege.

Governor Miller Signs New York's Water-Power Bills

Governor Miller of New York State has signed the two Robinson water-power bills recently passed by the legislature, one of which amends the conservation law in relation to the granting of licenses for the development of state-owned water power, and the other of which appropriates $1,000,000 for hydro-electric development at Crescent dam and Vischer Ferry, on the Mohawk River. In his memorandum on the first measure he said:

Perhaps the most important substantive change is the provision strengthening the power of the state to regulate rates and service and the use and distribution of power developed under a license. This is objected to on the ground that it will deter the investment of capital. The power of regulation is the power to which every public utility is subjected. If it turns out that capital is unwilling to invest under these conditions, it will be necessary to consider the alternative of state development.

On the second measure, he said:

The possible hydro-electric development is merely a byproduct of the larger enterprise whose primary purpose is navigation. The state has invested too much money in the navigation project to incur even a remote risk of subordinating the needs of navigation in the slightest degree to the development of water power. Prospective barge operators on the barge canal must be given no reason to entertain the slightest fear of such a hazard. There is only one way to avoid that risk, and that is by state development and ownership of both projects and the absolute control of both by the superintendent of public works.

We should not be deterred from stopping waste by the "bogey" of state ownership, nor should we incur the risk of subordinating the needs of navigation to power development incident to the introduction of a private power plant with a capacity of developing all the power available from the fear that the state cannot efficiently install and operate power plants to develop 10,000 hp. Those plants can be operated by the force which the state will have to maintain on the canal in any case, and if private capital will not enter the larger field under conditions safeguarding the public interest, the state may get some experience which will be useful to it later on, if forced to enter the field also.

Private capital need have no fear of competition with the state. The maximum development of surplus canal waters possible is only about 40,000 hp. A part of that will be needed for the operation of locks, bridges and the like. The distributing companies will be the natural customers for the surplus, if they treat the state and the public fairly.

Novel Engine Foundation

As is well known, the soil along the lower Mississippi, including New Orleans, is composed of silt carried down from the upper reaches of the river. In addition much of the country is lower than the river bed. Infiltration of water from the river makes this ground very unsubstantial, and it is impossible to have any great building weight rest on it without danger of displacement.

The Citizens Light and Power Co., New Orleans, is engaged in building a power house in Carrolton, a division of New Orleans, with the intention of carrying the industrial load in that part of the city. The generating units are four 750-hp. Busch-Sulzer two-cycle Diesel engines, each direct-connected to a 625-kva. Allis-Chalmers alternator with the exciter mounted on the shaft extension.

The engineers were confronted with the problem of a proper support for these units, the decision finally arrived at providing for the driving of a set of piling. A total of 170 piles were driven 50 ft. into the soil and a 3-ft. concrete mat placed over the pile heads. The foundation for each unit is mounted on and tied together by this mat, thus obtaining maximum bearing surface and mass to eliminate displacement and vibration.

The St. Cloud Public Service Co. has applied for a preliminary permit to build a concrete dam, with Tainter gates, with a head of 30 ft., at the Rigby site, in the Mississippi River just above Clearwater, Minn.

A.S.M.E. Spring Meeting to Herald Southern Progress

Realization of the growing industrial activity and importance of the South was evidently the guiding thought in the choice of the city and the arrangement of the program for the Spring meeting of the American Society of Mechanical Engineers. The city is Atlanta, Georgia; headquarters will be in the Piedmont Hotel. The date of the meeting itself is May 8-11; but before that, on May 5 and 6, there will be a meeting at Charlottesville, Va., and an automobile tour through the surrounding country; and after the main meeting, on May 12, there will be alternative trips to the textile mills of Greenville, S. C., and to the blast furnaces of Birmingham, Ala.; finally, on May 13, an excursion will be made to the great Muscle Shoals development, the white elephant that is now causing Congress so much concern in comparing the various offers made for taking it over.

The first day of the meeting, Monday, May 8, will be given over to registration, to a business meeting and to a get-together dinner in the evening. Then, beginning with Tuesday, there will be three days of technical sessions, to which power engineers will be attracted by the following papers.

Tuesday, General Session I: "Accuracy of Boiler Tests," Alfred Cotton; "Turning Exhaust Losses Into Work in Reciprocating Engines," J. Stumpf and C. C. Trump.

Wednesday, General Session II: "The Muscle Shoals Nitrate Plant and the Nitrogen Supply," Maj. J. K. Clement; "Insulation Losses from Pipe Coverings," R. H. Heilman; "Evaporation of a Liquid Into a Gas," W. K. Lewis (by title only). Fuels Session: "Reduction of Fuel Wastes in the Steel Industry," F. G. Cutler; "The Control of Boiler Operation," E. A. Uehling; "Boiler-Room Performance and Practice at Colfax Station, Duquesne Light Co.," C. W. E. Clarke.

Thursday, Power Session: "Power Development in the Southeast," Charles G. Adsit; "Economics of Water Power Development," C. A. Mees; "New Developments in Hydroelectric Design," John A. Sirnit; "Report Upon Efficiency Tests of a 60,000-Kw., Cross-Compound, Triple-Cylinder Steam Turbine," H. B. Reynolds and W. F. Hovey (by title only). Symposium on Welding: "The Strength of Electrically Welded Pressure Containers," R. J. Roark; "Some Principles of the Construction of Unfired Pressure Vessels," S. W. Miller. "Tests on Welded Cylinders," E. A. Fessenden and E. J. Bradford. (Under auspices A.S.M.E. Boiler Code Committee and American Welding Society)

Other papers will deal with management and with textiles, and particularly, like Mr. Adsit's paper on "Power Development in the Southeast," with problems and activities of the South.

In addition to the usual dinners and dances and theater parties, there will be: Excursions to points of more than ordinarily picturesque and historical interest, including the famous Stone Mountain; a golf match in which Bobby Jones and Perry Adair will show what they can do with Stewart Maiden and Howard Beckett (and six golf courses will give everyone a chance); and a real Southern barbecue, Wednesday afternoon, at the East Lake Club.

The business meeting, to be held Monday afternoon, will be made important by discussion of the new, condensed constitution, which will be presented for a first reading, and by reports of the committee on a code of ethics and of other committees, including several on standards.

Sessions will begin at 9:30 a. m. A registration fee of $2 will be charged, as at the last annual meeting. The national headquarters of the Society are at 29 West 39th St., New York City.

Central station output during January was 1.3 per cent less than in December, but a record was made in point of gross income, which reached $92,700,000. The slightly reduced demand was due to a considerable decrease in lighting requirements, although the industrial load increased, having reached the highest point since October in most primary industries.

O. C. Merrill Tells How Water Power Is Being Developed

A review of the work of the Federal Power Commission up to date was recently made by O. C. Merrill, executive secretary of the Commission, in a public address in which he outlined the situation as follows:

There have been filed with the Commission 213 applications for preliminary permit and 81 applications for license, or a total of 294. After deducting conflicting applications and those rejected or withdrawn, there is left an aggregate of 12,660,000 primary horsepower and 19,400,000 horsepower of estimated installation. These applications affect 34 states, the District of Columbia and the Territory of Alaska. The projects applied for vary from less than 100 hp. to the series of projects totaling some 4,500,000 hp. of the Southern California Edison Co. on the Colorado River.

Nineteen million horsepower is twice the total of water horsepower installed in the United States to date. It exceeds the combined potential waterpower resources of Norway, Sweden and Finland and the Arctic and Baltic drainages of Russia. It is nearly twice the combined resources of France and Italy. It is six times the aggregate of all applications filed for power sites under Federal control in the preceding 20 years.

Nearly one-half of the aggregate of nineteen million horsepower is represented by applications upon the St. Lawrence, the Columbia and the Colorado Rivers. Action upon these applications has, in general, been suspended. The St. Lawrence involves international relations and may require a treaty before final action can be taken. The Columbia is under investigation by a special board to determine the relations between power and irrigation use of its waters before applications are approved. Action on the Colorado River applications is awaiting the findings of the Colorado River Commission, an organization created by Act of Congress for the purpose of proposing a compact between the states within the Colorado Basin by which the water of the river may be apportioned among these states.

Of the licenses authorized, twenty, with an aggregate of 600,000 primary horsepower and an aggregate estimated installation of 1,420,000 horsepower, are either already completed or under construction. This amount is greater than the total built under Federal authority in all our previous history.

The projects built or under construction involve aggregate expenditures well in excess of $100,000,000. In fact one licensee alone proposes to expend $22,000,000 during the current year largely upon or in connection with the projects under license; and this at a time when industry is just recovering from a period of severe depression.

A chance to take a free one-year course in industrial teaching that leads to a license for life to teach in the vocational schools of New York State, with $1,000 for the year's expenses, is offered by the Director of Vocational and Extension Education, State Department of Education, Albany, N. Y., from whom further information may be obtained. Applicants must have had at least five years' practical experience in electrical construction, repairing and operating, or in other occupations. Salaries paid vocational teachers in New York State now range from $1,800 to $3,500 per year.

The Mount Spokane Power Company, of Spokane, Wash., is to build a 650-hp. power plant, which, with other betterments and extensions, will call for an expenditure of about $20,000, according to M. F. Mendenhall, the president. The company now supplies Deer Park, Milan, Milltown, Chattarey, Dennison and five pumps of the Arcade Irrigation Co. The new plant will be in the canyon of the Little Spokane River, between Milan and Chattarey, where there are two falls, each about 25 ft. high, and where the company already has a 400-hp. plant.

To get accurate figures on the stream flow of the Colorado River, the United States Geological Survey has established twelve base gaging stations, six on the main river and six on the tributaries. Secondary stations will later be established for special work.

News in the Field of Power

Customs Court Decides Engine Case

The Court of Customs Appeals has decided a case brought by the Columbia Shipbuilding Co., in which certain steam engines and fans or blowers designed to be operated together for supplying a forced draft to the boilers of vessels were involved. They were assessed by the customs collector as entireties and dutiable at 20 per cent as manufactures of metal. The importers protested that the merchandise should be segregated for duty and the steam engines assessed at 15 per cent as such. The Board of General Appraisers overruled the importers' protest, but its decision was reversed by the court, insofar as it relates to assessment of steam engines.

The Union Iron Works Fire

Further particulars regarding the fire at the Union Iron Works, of Erie, reveal that the main building, approximately 600 ft. long, with a 250 ft. ell, was destroyed. The fire started in the riveting tower, and, notwithstanding the small amount of combustible material in the main building, gained rapid headway and was very destructive. The loss is covered by insurance. The company still has its complete stack and tank shop, flanging department, blacksmith shop, castings department, warehouse, store house, power house and office intact and unharmed. It is proceeding with the work of filling all orders without interruption, and is in position to make reasonably prompt delivery on all new inquiries and orders that may be booked. Offers of assistance and service were received from the Erie City Iron Works, B. B. Nagle, the General Electric Co., and the Connelly Boiler Co., and George W. Bach, vice president and general manager, writes: "After all, this is a pretty good old world, when your friendly enemies will come clean and extend you a helping hand in your hour of trouble."

New Central Station for Amory, Mississippi

Municipal improvements are steadily increasing, thanks to the continued wide demand for municipal bonds, and the South is receiving her full quota of the tremendous sums invested in securities of this nature. A case in point is Amory, Miss., where a bond issue of $90,000 has been authorized to finance a complete light, water and power plant.

The new power machinery will consist of a 175 b.hp. engine and a four-cylinder 225-b.hp. engine, both of the vertical, four-cycle Fulton Diesel type. The smaller engine will be direct-connected to a 146-kva. alternating-current generator with belted exciter, and the larger engine will be direct connected to a 187½-kva. generator of the same type, also with belted exciter.

The low fuel consumption and other money-saving advantages of the Diesel Engines were the influences that dictated the choice of engines.

Electrical Show in Urbana

The Eighth Biennial Electrical Show of the Electrical Engineering Society of the University of Illinois, Urbana, is to be held April 20-22. The first of these shows was held twenty years ago, and it is reported that each succeeding one has been bigger and better than the one before it. Over 300 students have been working since October in preparation for this one, and an unusually interesting collection of instructive and freak exhibits is promised. One of the features will be a Tesla coil with a 10-ft. spark gap and an estimated voltage of 1,000,000 volts.

Dean Kimball Says—

"I have every confidence that the engineer will rise to his opportunity, and there are many signs that these ideals are stirring in the minds of forward-looking engineers. It is with no small gratification that we see the elevation of our past president, James Hartness, to the gubernatorial chair of his own state, and see Mr. Hoover, an engineer by training and experience, invited to enter the Cabinet of President Harding. These are pioneer workers in a field where the lawyer and the politician have long reigned supreme, and their stewardship will be watched by all engineers and others with great interest. It is an auspicious beginning that should hearten all who believe in the application of scientific methods to all problems of human existence — *Conclusion of the speech recently delivered over the radio telephone from Schenectady, N. Y., by Dexter S. Kimball, dean of the college of engineering at Cornell and president of the American Society of Mechanical Engineers.*

Safety Engineers Now Affiliated with A. S. M. E.

The American Society of Safety Engineers, with about 600 members, has become affiliated with the American Society of Mechanical Engineers with the approval of the governing bodies of both societies.

According to the provisions of the A. S. M. E. bylaws, under which the affiliation was carried out, the safety engineers' society has complete independence under its own constitution and bylaws, and the A. S. M. E. is not responsible for its acts; but its papers and discussions may be printed at cost in *Mechanical Engineering* when passed by the Publications Committee of the A. S. M. E., and the safety engineers may receive *Mechanical Engineering* on the same terms as other affiliates.

Water Power Applications

The Pacific Power and Light Co., of Portland, Ore., has applied to the Federal Power Commission for a preliminary permit to cover a large power project on Snake river. The proposal is to erect ten concrete dams between the Grande Ronde River and a point twenty miles below Homestead, Ore. In that distance a fall of 600 ft. would be developed, it was stated in the application. The project will develop 400,000 hp. of primary power, it is estimated. The plan is to install equipment necessary to generate 650,000 hp. The power is to be used for public-utility purposes.

G. M. Thomas, of Marianna, Fla., has applied for preliminary permit covering a dam and power house that he proposes to build on the Chipola River, eleven miles below Marianna. The primary power of the project is estimated at 2,000 hp., 6,000 hp. to be installed.

Alfred Noble Tablet in New York Engineers' Building

With impressive addresses, a memorial tablet to Alfred Noble was recently unveiled in the Engineering Societies Building in New York City. It was presented by the American Institute of Consulting Engineers. Dr. Alexander C. Humphreys, president of the Institute, formally presented custody of the tablet to the United Engineering Society, for which it was accepted by J. Vipond Davies, president. The tablet carries this inscription:

Alfred Noble, 1884-1914. An upright man, a good citizen, an eminent engineer, whose life and labors contributed greatly to the high honor of his profession and to the success of many important public works.

The tablet also outlines the more important of Mr. Noble's services, which were all in the field of civil engineering.

One of the finest pieces of industrial literature that has come to our sanctum is the volume commemorative of the completion of a half-century of existence by the Hendey Machine Co. The salesman has been suppressed and the history and development of the company unfolded in a story as interesting as a novel. Its dress will entitle it to a place upon anybody's bookshelf.

New Publications

The Smoke Problem, Report of the Bureau of Mines, Serial 2323. By O. P. Hood, chief mechanical engineer of the Bureau. Obtainable from the Bureau of Mines, at Washington.

A brief summary of the work that has been done toward smoke prevention, most of the conclusions of which were published on page 463 of *Power* for March 21. It is mentioned here, however, because it gives a list of a number of other publications and articles on the smoke problem.

Refuse Collection and Disposal. By Robert Balmer, President, The Balmer Corporation. Published by The Balmer Corporation, 150 Nassau St., New York City. Paper, 5½ x 8 in.; 18 pages. Distributed on request.

The part of this booklet of interest to power-plant men is its suggestion for combining power development with refuse combustion. No description of the apparatus is given, although that may doubtless be obtained upon request, but a few figures are given indicating that with a Balmer refuse destructor plant of a thousand tons daily capacity, a net production of 43,420,000 kw.-hr. per year has been obtained.

Pulverized Coal Systems in America (revised edition), 1922. By Leonard C. Harvey. Published by His Majesty's Stationery Office, Imperial House, Kingsway, W.C. 2, England. Paper; 7½ x 9¾ in.; 117 pages; 25 illustrations and numerous tables. Price 5 shillings 3½ pence, postage paid to America.

For an American to send to a foreign country to get the latest information on American pulverized-coal systems may seem to be a strange procedure. Nevertheless, such a course seems advisable for engineers who wish to keep in touch with practical developments along this line. In 1918 Mr. Harvey, the author of this book, made a special trip to the United States to investigate the status of pulverized fuel in this country. These investigations, which were made with the co-operation of the British Fuel Research Board, were continued without a break for three months, during which time Mr. Harvey traveled extensively and visited many plants using powdered fuel for a variety of purposes. In 1920 Mr. Harvey sent a circular letter and questionnaire to a large number of American users of pulverized coal. The information thus obtained is incorporated in the present volume.

The book appears to be an unbiased and thorough study of the subject from all angles. Practical considerations, such as operating difficulties and operating costs, are kept constantly in mind and the information given is of the specific variety desired by the man who is considering the advisability of changing to powdered fuel. The use of powdered coal in power-plant boilers is only one phase of the field covered by this book, which discusses with equal fullness its applications in locomotives, metallurgical operations, lime and fertilizer burning, etc.

Obituary

Dr. William Newton Best, inventor, and authority on oil-burning apparatus, died April 12, in Brooklyn, N. Y., where he had lived. He was president and consulting engineer of the W. N. Best Furnace and Burner Corp., 11 Broadway, New York City. He was a member of the American Institute of Mining and Metallurgical Engineers and of many other organizations in this country and in England, and was the author of a recently published book, "The Science of Burning Liquid Fuel."

Personals

William M. Moody, having left Chas. C. More & Co., San Francisco, is now with The Pelton Water Wheel Co.

James P. Brady has left J. N. Knight & Son and has gone into business for himself, dealing in power and ventilating apparatus.

J. K. Haigh, San Francisco district manager of the Chicago Pneumatic Tool Co., dropped into *Power's* office recently on the eve of his return to the Coast.

F. M. Mason, chief engineer of the Central Maine Power Co., and prominent for fifteen years in power development work in Maine, has been elected president of the Maine Association of Engineers.

Lyle A. Whitsit is now with the Adirondack Power and Light Corporation, of Amsterdam, N. Y., where he will study proposed extensions of the system. He was on the engineering staff of the Superpower Survey.

Dr. Robert H. Fernald, of the mechanical engineering department of the University of Pennsylvania and a prominent authority in the power-plant field, has been nominated for the presidency of the Engineer's Club of Philadelphia.

Roy M. Godwin, previously mechanical engineer for the Barrett Co., Frankford, Philadelphia, Pa., now has charge of claim, safety and fire protection for the Northern Indiana Gas and Electric Co., Fort Wayne, Ind., and also of the plants of the Lima Gas Co., Lima, Ohio.

Paul G. Sorsby has been appointed turbine and generator expert for the International General Electric Co., with headquarters at Yokohama, Japan. He is a technical graduate and has had fourteen years' engineering experience, and has left the position of guarantee engineer in the General Electric Co.'s turbo-electric ship propulsion division.

E. P. Cox and Nelson J. Darling have succeeded Richard H. Rice, who was manager of the Lynn (Mass.) plant of the General Electric Co. up to the time of his recent death. The Lynn works have been divided into two sections, to be known as the West Lynn Works and the River Works, which will be in charge of Mr. Cox and Mr. Darling respectively. Mr. Cox had been closely associated with Mr. Rice for several years at West Lynn, and Mr. Darling was formerly assistant manager of the company's works at Erie, Pa.

Society Affairs

Coming Conventions

American Institute of Electrical Engineers, 29 West 39th St., New York City. Spring convention at Chicago, April 19-21.

American Society of Mechanical Engineers, 29 West 39th St., New York City. Spring meeting at Atlanta, Ga., May 8-11.

American Water Works Association, 153 West 71st St., New York City. Annual convention at Philadelphia, May 15-19.

National Electric Light Association, 29 West 39th St., New York City. Annual convention at Atlantic City, N. J., May 15-20.

American Order of Steam Engineers; Andrew Lauterbach, 4726 North Warnock St., Philadelphia, Pa. Annual convention and exhibition at Philadelphia, June 5-9.

National District Heating Association; D. L. Gaskill, Greenville, Ohio. Annual convention at Cedar Point, Ohio, June 20-23.

American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa. Annual meeting at Atlantic City, N. J., June 26-July 1.

Canadian Association of Stationary Engineers; G. C. Keith, 51 Wellington St. West Toronto, Ont. Annual convention and exhibition at Kitchener, Ontario, June 27-29.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual conventions and exhibitions of the State Associations scheduled as follows:

New Jersey, at Elizabeth; June 2-4; E. J. Flynn, 423 Newpoint Road, Elizabeth, N. J.

New York, at New York City, June 8-10; T. J. Condon, 102 Seventh Ave., New York City.

Indiana, at Anderson, June 9-10; Frederick L. Ray, Anderson, Ind.

Michigan, at Kalamazoo, July 19-21; A. M. Adams, 1307 Stockbridge Ave., Kalamazoo, Mich.

Vancouver Section, A. I. E. E., is to meet May 5 for a paper by James Stott on "The A. C. Potentiometer."

Atlanta Section, A. I. E. E., is to meet April 27 for a lecture on "Modern Dam Construction," by R. S. Burroughs, of the Ambersen Construction Co.

Colorado Section, A. S. M. E., will meet April 28 at the Metropole Hotel in Denver for a talk on "Modern Steam Boilers," by W. T. Reilly, of the Babcock & Wilcox Co.

New Haven Branch, A. S. M. E., will meet April 26 to hear Prof. H. F. Moore, of the University of Illinois, describe the methods used and the conclusions reached in the study of the fatigue of metals made at the University.

Cincinnati Section, A. S. M. E., will meet April 27 at 25 East Eighth St. for addresses on "The Theory of Lubrication and Bearing Material," by Forrest E. Cardullo, of the G. A. Gray Co., and on "Ball Bearings," by Dr. Tobias Dantzig, of the S. K. F. Industries.

Washington (D. C.) Section, A. S. M. E., is to meet April 27 in the Interior Department Auditorium. F. H. Rodgers, hydraulic engineer with the Wm. Cramp and Sons company, will speak

on "Turbine Development," and E. C. Bebb and Charles E. Oakes, Federal Power Commission engineers, will speak on "The Efficient Use of Water Resources by Electrical Interconnection of Utilities."

Business Items

The Anderson Foundry and Machine Co., of Anderson, Ind., manufacturers of the Anderson oil engine, have opened a branch house at 2825 West Harrison Street, Chicago, Ill., with R. E. Gray as manager.

The Chain Belt Co., Milwaukee, Wis., has appointed G. F. Sherratt as manager of the Pittsburgh Office in the Union Arcade Building. Mr. Sherratt will be in charge of all the company's chain and engineering business in the Pittsburgh territory.

Trade Catalogs

Cooling Towers—Edwin Burhorn Co., 25 West Broadway, New York City. 1922 catalog, 38 pages, with a large number of interesting photographs showing Burhorn towers installed.

Temperature Regulator—Sarco Co., Inc., Woolworth Bldg., New York City. Bulletin A-70, describing various types and applications of temperature-control apparatus and some other products.

Commutator Grinding and Slotting—Martindale Electric Co., 11737 Detroit Ave., Cleveland, Ohio. A four-page circular on Imperial commutator stones and on three devices for undercutting mica.

Valve Control Apparatus. — Payne Dean Limited, 103 Park Ave., New York City. Bulletin 43-A, describing electrically operated apparatus for opening or closing gate valves at a distance, for showing the position of such valves or of the level of water in a reservoir at a distance and for maintaining a constant level in a tank or reservoir by an electrically operated valve some distance away, controlled by a float.

Vertical Steam Engines—Engberg's Electric and Mechanical Works, St. Joseph, Mich. A 36-page catalog describing in considerable detail these engines, which are made in sizes from 1 to 100 hp.

Spray Towers—Binks Spray Equipment Co., 3114-26 Carroll Ave., Chicago, Ill. Short bulletin, No. 43, on a spray tower suitable for cooling from 10 to 60 gal. per min. of circulating water for small ice machines, oil engines, electrical transformers and similar apparatus.

Evaporator Systems — Griscom-Russell Co., 90 West St., New York City. Bulletin No. 360, which states briefly the advantages of using evaporators for distilling boiler-feed water, and explains the difference between the pressure and the vacuum systems.

Storage Heaters — Griscom-Russell Co., 90 West St., New York City. Bulletin No. 241, explaining the construction and advantages of the Russell storage heater, in which a small quantity of exhaust steam gradually heats up a large quantity of water, which may be used when necessary.

A.C. and D.C. Motors—Ideal Electric and Manufacturing Co., Mansfield, O. Two 24-page bulletins, Nos. 102 and 103, on direct-current motors and generators, and squirrel-cage and slip-ring induction motors, respectively. The apparatus is described in detail, but there is included also some valuable educational material, particularly in 103, which explains how electrical data are obtained from the Heyland diagram.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	April 3, 1922	April 10, 1922
Pool 1,	New York	$2.85	$2.65@3.00
Pocahontas,	Columbus	1.85	2.00@2.25
Clearfield,	Boston	1.95	1.65@2.40
Somerset,	Boston	1.90	1.70@2.50
Pittsburgh,	Pittsburgh	1.85	.....
Kanawha,	Columbus	1.45	1.40@1.65
Hocking,	Columbus	1.75	.....
Pittsburgh No. 8	Cleveland	1.80	1.75@1.85
Franklin, Ill.,	Chicago	2.40	2.50@3.00
Central, Ill.,	Chicago	2.25	2.50@2.75
Ind. 4th Vein,	Chicago	2.35	2.40@2.50
Standard,	St. Louis	1.80	1.85@1.95
West Ky.,	Louisville	1.85	1.80@2.00
Big Seam,	Birmingham	1.70	1.50@1.90
S. E. Ky.,	Louisville	1.55	1.65@1.70

New York—Apr. 13, Port Arthur light oil 22@25 deg. Baumé 3¾c. per gal.; 30@35 deg., 4¾c. per gal., f.o.b. Bayonne, N. J.

Chicago—Apr. 5, for 24@28 deg. Baumé, 85@90c. per. bbl.; 21@36 deg., 2⅜@2½c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh — Apr. 10, f.o.b. refinery, Pennsylvania, 36@40 deg. 4¾@5c. Kentucky fuel oil, 26@30 deg., 3½c. per gal. Western, 24@30 deg., 85c. per bbl.; 32@34 deg., 3c. 36@38 deg., 3½c. 38@40 deg., 3¾c. per gal.

St. Louis—Mar. 25, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 90c. per bbl.; 26@28 deg., 95c.; 28@30 deg., $1.10; 32@34 deg. 2¾c. per gal.

Philadelphia — Apr. 10, 26@28 deg. Baumé, Oklahoma, 82½@87½c. per bbl.; 30@34 deg., Oklahoma (group 3), 2⅝@2¾c. per gal.; 16@20 deg. Seaboard, 90c.@$1 per bbl.

Cincinnati—Apr. 4, for 26@30 deg. Baumé, 4½c.; Diesel 32@36 deg., 4½c. per gal.; distillate 38@48 deg., 5½c. per gal.

Cleveland—Apr. 4, 26@30 deg. Baumé, 3½c. per gal.

New Plant Construction

PROPOSED WORK

Ala., Tuskegee — The Treasury Dept., J. A. Wetmore, Supervising Archt., Wash., D. C., will receive bids until May 1 for the construction of U. S. veterans' hospital, estimated cost, $1,450,000; mechanical equipment $750,000; hospital to include officers' quarters, administration building, mess hall, nurses' quarters, etc. Noted Feb. 7.

Cal., Marysville—The Chamber of Commerce and a corporation of business men have commissioned Ward & Blohme, Archts., 454 California St., San Francisco, to prepare plans for a 5 story hotel. About $250,000.

Cal., Riverside—The city voted $500,000 bonds for the construction of elementary school and improvements to power building.

Cal., Sacramento — The Sutter Hospital Assn. is having plans prepared for a 3 story, 160 x 320 ft. hospital on L St. between 28th and 29th Sts. About $300,000. Meyer & Johnson, 742 Market St., San Francisco, Archts.

Cal., San Francisco—The Southern Pacific Co., S. P. Bldg. and Pacific Fruit Express Co., 65 Market St., is having plans prepared for an ice plant on Bakersfield St. About $400,000. W. C. Phillips Co., 311 California St., Engr.

Cal., San Francisco—The state is having plans prepared for a state normal school on Waller St. between Buchanan and Laguna Sts. About $1,000,000. State Department of Engrs., Forum Bldg., Sacramento, Engrs.

Cal., San Luis Obespo—The Tripoli Hotel Co. is having plans prepared for a group of 1, 2, 3 and 4 story hotel buildings including an electric heating system. About $500,000. Eldridge & Jewell, 226 Pacific Finance Bldg., Los Angeles, Archts.

Cal., San Rafael—The San Rafael Ice Co., E. P. Grady, Pres., plans to build a 50 x 100 ft. ice plant, 15 tons per day capacity. About $50,000. Architect not selected.

Cal., Stockton—The city plans election May 5 to vote bonds for the construction of a dam for flood control. About $1,300,000. W. B. Hogan, City Hall, City Engr.

Col., Denver—T. M. Patterson Estate, Patterson Bldg., is having plans prepared for a 10 story, 100 x 125 ft. office building on 17th and Welton Sts. About $650,000. Montjoy & Frewen, Chamber of Commerce Bldg., Archts.

Conn., New Britain—The Bd. Educ. will receive bids until April 25 for a 3 story schoolhouse on Washington St. About $367,000. D. K. Perry, 27 West Main St., Archt. Noted Jan. 3.

Ga., Thomasville—The city, H. J. McIntyre, Mayor, will receive bids until April 24 for a 2 story, 104 x 160 ft. power plant. C. F. Galliher, 1st Natl. Bank Bldg., Montgomery, Ala., archt.

Ia., Maquoketa—The town plans election April 26 to vote $70,000 bonds to extend electric lighting system.

Ind., LaFayette—Pond & Pond, Archts., 64 East Van Buren St., Chicago, Ill., will soon receive bids for a 3 story office building including a steam heating system for the Union Student Bldg. About $1,000,000.

Ill., Carbondale—The Roberts Hotel, c/o A. S. Roberts, plans to build a 5 story hotel including a steam heating system. About $350,000. Architect not selected.

Ill., Chicago—Herman Emerman, c/o M. Levy & Bro., Adams and Dearborn Sts., plans to build a 141 x 268 ft. hotel including a steam heating system on Lake Shore Drive. About $2,000,000. Architect not selected.

Ill., Chicago—The Natl. Stamping & Electric Co., 424 South Clinton St., F. L. Kohlhase, Purch. Agt., is in the market for one 1,000 ampere plating dynamo operating at a speed of 900 r.p.m.

Ill., Chicago—The Wolf Furniture Co., 3237 Lincoln Ave., plans to build a 6 story, 48 x 200 ft. store building including a steam heating system at 3165 Lincoln Ave. About $500,000. Architect not selected.

Ky., Sturgis—W. Herbert, is in the market for a complete line of coal mining machinery including hoists, conveyors, washing machinery, mine and power plant equipment.

Mass., Boston—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will receive bids until April 26 for a sub-station, distribution system and first aid station here. Noted Nov. 22. Spec. 4550.

Me., Six Miles Falls—Corson Bros. & Co., Bangor, plans to build a hydro electric plant on the Kenduskeag River. Architect not selected.

Mich., Ann Arbor—The Bd. of Regents, University of Michigan, will receive bids until April 20 for a 4 story, 189 x 248 ft. engineering building, shops and laboratory, including a steam heating system, wiring for lights and power equipment for shops, two 3 hp. and one 40 hp. motors. Smith, Hinchman & Grylls, 710 Washington Arcade, Detroit, Engrs.

Mich., Detroit—The Cass Bldg. Co., 406 Hammond Bldg., F. E. Miller, Pres., plans to build a 16 story, 100 x 150 ft. office building on Cass Ave. About $1,300,000. M. Harrison, 500 Bd. of Trade Bldg., Indianapolis, Ind., Archt.

Mich., Detroit—The Woodward-Larned Realty Co., c/o C. H. Crane, Huron Bldg., Griswold St., plans to build a 10 story office building including a steam heating system on Woodward Ave. and Larned St. About $400,000.

Mo., St. Louis—The Saxony Mills, 4th and Lombard Sts., plans improvements to power plant including the installation of one 200 kw. mixed pressure turbo generator unit with switchboard, jet condenser, spray pond or cooling tower and chain grate stokers. Total cost including equipment, $40,000. D. Larkin, c/o Larkin Engr. Co., 424 North 3rd St., Consult. Engr.

Neb., Lincoln—The council, W. J. Mohr, Clk., will receive bids until April 26 for furnishing and installing pipe line, pump machinery, and reconstructing old well. Alternate of one 20 hp., 220-440 volt, 3 phase, 60 cycle, 900 r.p.m. motor; one power head for 6¾ x 24 in. 2 plunger cylinder, or one power head for 1-6¾ x 24 in. double acting deep well cylinder. About $15,000. Hershey & Merick, Brownell Bldg., Engrs.

Neb., Lincoln—The Nebraska Material & Supply Co., 117 North 9th St., W. H. Bixby, Purch. Agt., is in the market for belt driven air compressor, cap. 50 c.f., 60 to 70 lbs. pressure (used).

N. H., Portsmouth—The Boston & Maine R. R. Co., North Station, Boston, plans to rebuild engine and round house at freight yards here. About $60,000. Private plans.

N. J., Camden—Lackey & Hettle Archts., 5 Hudson St., is preparing plans for a 3 story, 200 x 200 ft. apartment including a vapor heating system. About $350,000. Owners name witheld.

N. J., Gloucester—The Bd. Educ., c/o W. S. Bradway, will soon receive bids for a 2 story high school. About $350,000. Lackey & Hettle, 5 Hudson St., Camden, Archts.

N. Y., Brooklyn—The Natl. Foundry Co., 10 Sandford St., is in the market for an electric arc welding outfit with 7½ hp. and d.c. motor and generator.

N. Y., Brooklyn—The State Hospital Comn., Capitol, Albany, will receive bids until May 3 for a 4 story, 67 x 192 ft. hospital including heating, plumbing and electrical work for the Brooklyn State Hospital here. About $300,000. Noted March 21.

N. Y., Cattaraugus—F. E. Cobane, Jefferson St., is in the market for an air compressor and tank 200 lb. pressure.

N. Y., Chili Station—G. Peer is in the market for a boiler suitable for use in creamery.

N. Y., Freeport—The Bd. Educ. plans to build a high school on Pine St. About $600,000. Architect not selected.

N. Y., Johnson City—The Bd. Pub. Wks., H. Brown, Pres., is in the market for steam driven water pumps for water supply station.

N. Y., Lackawanna (Buffalo P. O.)—W. J. Lohr, 311 Ridge Ave., plans to build a 25 ton ice plant on Lehigh Ave. About $62,000. Also plans to build a 200 ton storage addition later.

N. Y., La Salle—A. Le Bar & Sons Co., Belden Ave. and River Rd., A. Le Bar, Purch. Agt., is in the market for machinery and equipment for artificial ice plant, 25 tons per day capacity.

N. Y., Locust Valley—The city plans construction of municipal water system, about 18 mi. of mains, with pumping station, tank, etc. About $330,000. S. B. Bowne, Mineola, Engr.

N. Y., New York — The Gotham Silk Hosiery Co., 516 5th Ave., plans to build a factory on 33rd St. and 1st Ave. About $250,000. Architect not selected.

N. Y., New York—J. T. Lee, c/o A. L. Harmon, Archt., 7 East 40th St., is having plans prepared for a 30 story hotel on Lexington Ave. and 48th St. About $4,500,000.

N. Y., New York—E. N. Tailer, Newport, R. I., is having plans prepared for a 9 story apartment including a steam heating system at 2-10 East 86th St. here. About $400,000. C. W. Buckham, 175 5th Ave., New York City, Archt.

N. Y., Watertown—The Northern New York Utilities, Inc., will soon award the contract for the construction of a dam, power house and installation of water wheel and electric generator units at Browns Falls. Cost between $400,000 and $500,000. Address J. P. Brownell, Consulting Engr., Strickland Bldg., Carthage.

O., Cleveland — The American Legion Bldg. Co., c/o R. H. Jamison, 2121 Euclid Ave., plans to build a 12 story club and office building. About $500,000. Architect not announced.

O., Cleveland—The Chester-Twelfth Co., c/o C. H. Quinlan, Swetland Bldg., is having preliminary plans prepared for a 12 story commercial and office building including a steam heating system on East 12th St. and Chestnut Ave. About $400,000. W. S. Ferguson Co., 1900 Euclid Ave., Archts.

O., Cleveland—H. A. Edwards, c/o W. S. Longee, Archt., 500 Marshall Bldg., is having preliminary plans prepared for a 12 story office building including a steam heating system on East 3rd St. and Lakeside Ave. About $350,000.

O., Cleveland—The Graphic Arts Trust c/o F. O. Nitch, 1104 Prospect Ave., is having plans prepared for an 8 story, 60 x 180 ft. commercial and loft building including a steam heating system at 1200 Bolivar Rd. About $300,000. E. McGeorge, 1900 Euclid Ave., Archt. and Engr.

O., Cleveland—The Penton Publishing Co., R. E. Power, Treas., East 12th St. and Chestnut Ave. is having plans prepared for a 9 story, 135 x 135 ft. publishing plant including a steam heating system on West 3rd St. and Lakeside Ave. About $500,000. F. Chase, 645 North Michigan Ave., Chicago, Ill., Archt. G. F. Burrows, 627 Hanna Bldg., Engr.

O., Cleveland—W. Vretman, East 45th St. and Prospect Ave., is having plans prepared for a 7 story, 80 x 160 ft. apartment including a steam heating system at 3328 Euclid Ave. About $1,000,000. G. Graham & Co., 8201 Cedar Ave., Archt.

O., Springfield — F. J. Drolla Co., 516 Fairbanks St., plans to build a 10 story, 50 x 65 ft. office building. W. E. Russ, Meridian Life Bldg., Indianapolis, Ind., Archt.

Pa., Allentown—The School Bd. c/o E. H. Helfrick, plans to build a 2 story junior high school. About $900,000. H. C. Richards, 608 Chestnut St., Phila., Archt.

Pa., Chester—W. E. Headly is receiving bids for a 5 story, 100 x 126 ft. warehouse including a steam heating system. About $500,000. C. Winder, 1415 Locust St., Phila., Archt.

Pa., Easton—The Bd. Educ. c/o R. E. Piefer, plans to build a 2 story, 200 x 250 ft. junior high school. About $350,000. H. C. Richards, 608 Chestnut St., Phila., Archt.

Pa., Homestead—The borough, J. M. Rice, Oliver Bldg., Pittsburgh, Consulting Engr., is in the market for a 4,000,000 gal. pump.

Pa., Phila.—Hoffman-Henon Co., Archts., Finance Bldg. are receiving bids for a 3 story, 111 x 119 ft. school including a steam heating system on 45th and Wyalusing Sts. for Our Mother of Sorrows R.C. Church, c/o R. N. Fisher, 45th and Lancaster Ave. About $350,000.

Pa., Phila.—P. M. Myers, Franklin and Poplar St., representing owner, plans to build a 12 story, 74 x 117 ft. apartment house on 13th and Spruce Sts. About $1,000,000.

Tenn., Nashville—The city, J. O. Lankard, Comr. of lights and lighting, City Hall, has appropriated $90,000 for rebuilding electric power plant on 1st Ave. T. J. Pentecost, Supt. of plant, Nashville. New equipment to be purchased for entire plant. Noted March 7.

Tenn., Nashville—The Union Ice Cream Co., 817 Broad St., is having plans prepared for a 3 story ice cream factory on 12th and Broad Sts. About $200,000. Man & Holman, Stahlman Bldg., Archt.

Va., Hopewell—The Hopewell Ice & Cold Storage Co., W. C. Ellis, Mgr., plans to build a 1 story, 25 x 100 ft. ice plant. Cost between $40,000 and $50,000. Architect not selected. Is open for quotations on electrically operated machinery.

Va., Norfolk—J. B. Porter, P. O. Box 255, is in the market for various small tools for tinning work, also about 40 hp. tubular boiler (used).

Va., South Norfolk (Norfolk P. O.)—The city, F. L. Rowland, Mayor, will receive bids until April 20 for part of sanitary sewerage system: electrical automatic equipment for pumping unit, erection of pumping building and collecting well, discharge line, and 11¾ mi. 8 to 20 in. pipe sewer. About $135,000. G. H. Massey, 408 McKevitt Bldg., Norfolk, Conslt. Engr.

Va., Wytheville—R. P. Johnson, O. M. Johnson, Purch. Agt., is in the market for a 70 to 80 hp. return tubular boiler complete with all fittings and fixtures to carry not less than 100 lb. steam pressure and 100 hp. return tubular boiler complete.

W. Va., Wheeling—The city plans election April 20 to vote $2,000,000 bonds for a rapid sand filtration system, improvements to waterworks, new mains, etc. J. N. Chester Engineers, Union Bank Bldg., Pittsburgh, Engrs. Incorrectly noted March 21.

Wis., Delavan—The Water Comn., K. Hollister, City Clk., will receive bids until April 21 (change of date) for waterworks improvements including a 30 in. diameter open well, pumping station and ¼ mi. of 8 in. force main, also 400 gal. per min. motor driven centrifugal pump. W. A. Peirce, Engr. Noted April 4.

Wis., Horicorn—G. Shonts is having plans prepared for a 2 story, 50 x 75 ft. sausage factory and refrigerating warehouse on Main St. Power and refrigerating machinery, motors, etc., will be required. About $60,000. Private plans.

Wis., Marshfield—The Blum Bros. Co., 135 West 9th St., will receive bids about May 1 for a 1 and 2 story, 96 x 120 ft. butter tub factory including a steam heating system. About $100,000. G. A. Krasin, Archt. Woodworking machinery, power machines, motors, etc., will be installed.

Wis., St. Francis (Milwaukee P. O.)—The Milwaukee Electric Ry. & Light Co., 2nd and Sycamore Sts., will soon award contract for a 1 story, 50 x 60 and 60 x 70 ft. addition to switch house and turbine room.

Ont., Crediton—The council, H. Eilber, plans electric lighting and power distribution system. About $35,000. J. N. Wilson, 190 University Ave., Toronto, Engr.

Ont., Niagara Falls—The Hydro Electric System of Niagara Falls is receiving bids for a 2 story, 45 x 110 ft. transformer station on South St. and Victoria Ave. About $125,000. C. M. Borter, 102 Main St., Archt. Electric equipment including transformers, switches, lighting arresters, etc., will be installed.

Ont., Port Dover—The council, J. Sloan, is having plans prepared for waterworks system including the installation of mains and pumping equipment. About $42,000. James, Proctor & Redfern, 36 Toronto St., Toronto, Engrs. Want prices on mains and pumping equipment.

Ont., Wilton Grove—Westminster Tp. council, G. Riddell, is having surveys made for an electric lighting and power distribution system. About $35,000. A. Purcell, 190 University Ave., Toronto, Engr.

CONTRACTS AWARDED

Ariz., Whipple Barracks—Treasury Dept., J. A. Wetmore, Supervising Archt., Wash., D. C., has awarded the contract for boilers and mechanical changes in cold storage and ice plant to F. G. Allin Constr. Co., Syndicate Trust Bldg., St. Louis, Mo., $6,147.

Pa., Phila.—S. R. Blockson, Arch St., has awarded the contract for a 15 story, 100 x 158 ft. hotel including separate power plant on Juniper and Locust Sts. to J. R. Wiggins & Co., Otis Bldg., $3,000,000. Noted March 7.

Wash., Tatoosh—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for a naval radio and radio compass station for operating and power buildings, walks, sewers and water systems to B. Ward, 418 Peoples Bank Bldg., Seattle, $14,880.85. Noted Feb. 21.

Ont., Kingston—The Kingston General Hospital and Queens University, has awarded the contract for a power house on King St. W. to Simmons Bros., 132 Princess St. About $50,000. Horizontal boilers will be installed. Noted Sept. 27.